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THE GARDENS' BULLETIN

STRAITS SETTLEMENTS

Vol. XI 29th November, 1940 Part 2

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THE
GARDENS' BULLETIN
STRAITS SETTLEMENTS

Vol. XI 29th November, 1940 Part 2

PALMÆ MALESICÆ

VIII.—THE GENUS LICUALA IN THE MALAY PENINSULA

By C. X. FURTADO
Botanic Gardens, Singapore

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1. Introduction

The results embodied in this paper are of a study undertaken with the view of arranging systematically the Singapore herbarium specimens of the *Licuala* species indigenous in the Malay Peninsula. The present world conditions, entailing the cessation of intercourse with certain botanical institutions, the dislocation of the staff at some others, and the risks to parcels during transit across oceans have precluded my obtaining either critical notes of the type specimens preserved outside the Malay Peninsula, or a loan of the specimens themselves. Under such limitations the results of my undertaking would have been of little systematic value but for the valuable assistance derived from BECCARI'S monographic work on the genus published first in an abbreviated form in *Webbia* V, 1921, pp. 22–55, as a part of *Recensione delle Palme del Vecchio Mondo Appartenenti alla Tribu delle Corypheae* and then in an extended form in the *Annals of the Royal Botanic Gardens, Calcutta,* XIII, printed in 1931 and published in 1933 (cited

below as *Calcutta Annals* or *Calc. Annals* XIII, 1933). In this latter work BECCARI incorporated the results of the opportunities he had not only of consulting the type material of most of the species he studied and of comparing newer material with it, but also of making lengthy critical descriptions, analytical drawings and photographic plates of such specimens.

2. Hints to Collectors

Licuala is a genus of small palms the largest of which attain about 15–20 feet in height and a few ($\pm$ 3) inches in stem diameter. However, most of the species are almost stemless or only a few feet in height. Compared therefore with the long, thorny rattans or tall giants like *Corypha, Borassus* and *Oncosperma,* the *Licuala* species present very few obstacles to the collector making good herbarium specimens. The tallest ones can be cut down with an ordinary jungle knife within a few minutes, and the specimens of leaves and of spadices with flowers and fruits do not form very weighty or bulky specimens. Though the petioles of most species are provided with thorns, yet the specimens are easily handled even without leather gloves, which are required in handling specimens of Rattans or *Oncosperma.* Hence one would have expected this genus to be well represented in most herbaria, and also to be specifically well known in areas botanically fairly well explored. From the study of the species in the Singapore herbarium and from the notes given by BECCARI, I conclude that this is far from the case. This country has been explored botanically for the last fifty years or more by different botanical collectors and I find the *Licuala* species are very badly represented in the herbarium. Even in regions botanically well known, species formerly not recorded are being discovered. The principal reason for this is that in the field most of the species look alike and are not easily distinguished one from another except when the collector has made a special point to study them in the field. The number of segments present on a leaf often depends on the age of the plant and to a certain extent on the conditions under which it grows. Many times really acaulescent species may be mistaken for others which flower and fruit when quite small or stemless. In many species, moreover, the flowers and fruits remain hidden among the leaves so that they may be passed as the sterile stages of others.

If the collector is therefore to see that he does not miss any uncommon species he meets with in the jungle, he must learn to distinguish the species in the field. To

do this satisfactorily the following pointers may be useful:—

1. The average number of main nerves (costae) radiating from the apex of the petiole is a more stable character than the average number of leaflets into which a leaf is divided, though the latter is sometimes useful in the identification of a species.
2. Some species have always undivided leaves (not noticed in any species wild in the Peninsula).
3. In some species the median segment of the leaf is three or more times as broad as the other lobes, in others the segment is nearly as broad as the other segments.
4. In some species the broad median segment is entire, in others it is divided half-way.
5. In some species the middle segment becomes distinctly petiolulate, in others it is always sessile.
6. In some species the lateral margins of the leaf segments are arcuately cuneate, in others the margins are straight.
7. Some species are always solitary, others form tufts.
8. Some are always stemless, others produce stems though they may begin to flower when stemless.
9. In some species the spadices reach high above the height of the leaves so as to become visible from a distance; in others the spadices remain hidden among the leaves.
10. In some species the spadices are simple, terminating with one or more floriferous branchlets (spikelets); in others the spadices are compound.
11. In some species the lower branches of the compound spadices are subdivided into 10 or more spreading spikelets; in some others the branches contain only 2–5, usually digitate, branchlets; in still others the branches are simple, undivided.
12. Different species are characterised by different colour of spadices, flowers and fruits.
13. In some the fruits are 3–4 times as long as they are thick; in others the fruits are globose.

In a given field, all Licualas may have many of the above-mentioned characters in common, but they will differ in others, which, though a few, will suffice to distinguish

between the species, even disregarding such variable characters as the height of the plant, and the nervation and the number of the leaf-segments. But it is desirable to record in the field notes as many particulars as possible concerning the habit, stem height (without leaves), etc., of the plants, size of the petioles, leaf-lamina and spadix, the average number of segments to a leaf, the average number of main branches to a spadix, the colour of fruits, flowers, etc.

For herbarium purposes the leaf specimens should be taken from flower-bearing crowns; and if there is some variation in size, etc., in the leaves of non-flowering crowns, some few specimens may be made to indicate this variation. Care, however, should be taken to use appropriate tags so that the leaves may be sorted and mounted in the herbarium according to their status without any fear of confusion (*vide* my remarks on numbering the specimens in the field in *Gard. Bull., Straits Settl.* IX, 1937 p. 155, 286–287, and 303 in example).

If it is desired to reduce the bulk of the specimens one may split the leaves longitudinally, taking care to leave the middle segment intact; the half without median segment becomes practically useless, unless the species is rare and a sufficient number of leaves is not available for making up the sets.

3. Subgenera and Sections

Apart from the collector's difficulties, the genus *Licuala* presents many difficulties to a systematist. There is a good deal of variation in the vegetative parts of the plants. Though the branching of the spadices frequently occurs in a definite manner and forms a useful character to differentiate between species, it is not one that can be employed to subdivide the genus into subgenera or sections; such a classification not only places very closely related species in different sections or subgenera, but also divides subgenerically or sectionally polymorphic specific units.

BECCARI, who in 1886 had relied on the branching of spadices to divide the genus *Licuala* subgenerically into EU-LICUALA (implicit), LICUALOPSIS, LICUACELLA and LICUALINA (*Malesia* III, 1886, pp. 69–90), was obliged in 1921 to reduce these subdivisions to two, namely, EU-LICUALA and LICUACELLA, the latter to include LICUALOPSIS and LICUALINA (*Webbia.* V, 1921, pp. 22–55). Here BECCARI made also a new subgenus DAMMERA, but the main character used to define this subgenus is derived from the flower. This disposition has also been adopted in BECCARI'S monograph published in the *Calcutta Annals*, XIII (1933). Leaving the subgenus DAMMERA out of consideration for

the present, this modified subgeneric division of *Licuala* is still unsatisfactory, because the basis used to distinguish these two subgenera is still the character of the branching of the spadices. Under such a classification, for instance, *L. lanuginosa* and *L. Kingiana* fall into two subgenera, when the species are so very closely related that they may be regarded as two varieties of the same species. Further, this classification obliges one to split such variable species as *L. modesta* Becc. *sensu lato* into *L. modesta* Becc. *sensu stricto* and *L. Wrayi* Becc. according to the development of the spadix, and then to place these two species thus defined into two different subgenera.

The other grouping of the *Licuala* species is one published by DRUDE (ENGL. u. PRANTL, *Pflanzenf.* II, 3, 1887, p. 35), subsequently modified by RIDLEY. DRUDE was apparently unaware of the subgenera published by BECCARI, for, without making any reference to the latter's subgenera, DRUDE proposed independently two subgenera, namely: EU-LICUALA to include the species with a dorsal embryo, and PERICYCLA (Bl.) Drude (spelt by error *Pericyla*) to include the species with a basilar embryo. The type of this second subgenus was *L. penduliflora* (Bl.) Miq., published previously as *Pericycla penduliflora* Bl. It is apparent that, in reducing *Pericycla* Bl. to a subgenus of *Licuala*, DRUDE relied on the characters mentioned by BLUME, who had examined the position of the embryo in the flower only, where the position is often misleading. I point this out because I have not seen any species of *Licuala* having a basilar embryo, and BECCARI, who had opportunities to examine a very large collection of fruiting specimens, does not mention any such species.

In 1903 RIDLEY reduced *Pericycla* Bl. to a section of *Licuala*, defining it to include all species having a "panicled inflorescence" (*Journ. Roy. Asiat. Soc., Straits Settl.*, 41, 1903, p. 42). The section was naturally typified on *L. penduliflora*, of New Guinea, for which RIDLEY adopted the name *L. pericycla* Zipp. Mss.; but the only Malayan species that RIDLEY included in the section was *L. paniculata* Ridl., though *L. longipes*, *L. paludosa*, etc. have inflorescences similarly branched. RIDLEY adopted this section also in his later works, *viz.*: the *Materials for a Flora of the Malay Peninsula, Monocotyledons* (cited below as *Materials* or *Mat.*), II, 1907, pp. 159–165, and the *Flora of the Malay Peninsula* (cited below as *Flora*), V, 1925, pp. 24–30. But if, following RIDLEY'S definition, one were to place all the species having "panicled inflorescences" in the section PERICYCLA, the group would consist of utterly unrelated species, several closely related species remaining outside.

In view of these drawbacks of previous definitions, an inquiry was made into the problem of subdividing the genus. The most stable characters were found to lie in the flowers, the nature of the divisions of the androecium affording characters to group the species into well defined subgenera. The utility of these characters was recognized by BECCARI (op. cit 1921 & 1933); but he employed them only in the analytical keys provided for the identification of the species, and not to define his subgenera. On the basis of these characters, I divide the genus *Licuala* into three subgenera, namely: LIBERICULA (new), EU-LICUALA and PERICYCLA. The second is further divided into four sections, but LICUACELLA is not retained.

I. LIBERICULA. Furtado **subgen. nov.**

Staminum filamenta 6 erecta aequalia, basi lata superne subulata, ad basin libera vel fere, nec in annulum prominentem ad corollæ faucem connata. Flores inter majores, circa 15 mm. longi, 5 mm. crassi.

Species unica, *L. peltata* Roxb., in regionibus humidis inter septentriones et orientem Indiarum spectantibus ex Assam, Khasia, Sikkim, etc. ad meridiem in Insulis Andamanicis, Tenasserim, et Thailandia (Siam) meridionali habitat.

II. EU-LICUALA Drude in Engl. u. Prantl, Pflanzenf. II, 3 (1887) 35; Ridl., Flora V (1925) 24 loco sectionis, nom. nud.

Licualopsis Becc., Malesia III (1886) 85.

Licualina Becc. op cit p. 88.

Licuacella Becc. op cit p. 86, in Webbia V (1921), 24 et 37, in Calc. Annals XIII (1933), 116 et 128. **Syn nov.**

Staminum filamenta 6, aequalia, erecta vel inflexa, ad corollæ faucem in annulum prominentem connata. Flores 3–8 mm. longi, 2 mm. crassi.

Sectio 1: **WURMBIA** Furtado **sect. nov.**

Annulus staminalis membranaceus, aut truncatus, apice in filamenta parva, erecta, filiformia productus, aut in filamenta erecta, lobiformia, abrupte subulata divisus. Antheræ haud aristatæ.

Inter divisiones *Licualae* hæc sectio species plurimas includens, qui in regionibus torridis et semitorridis ex Birmania, Thailandia (Siam) et China meridionale ad Celebesiam et Novam Guineam habitant, maximæ species in regionibus malayanis (viz. in Peninsula Malayana, Sumatra et Borneo).

Species typica: *L. spinosa* Wurmb.

Nomen hujus sectionis in honorem cl. F. VON WURMB, auctoris speciei typicæ.

Sectio 2: **BONIA** Furtado **sect. nov.**

Annulus staminalis brevis, crassus. Filamenta erectiuscula, lobiformia, elongata, subbulbosa, apicem in connectivum discoideum antherarum dorso adnatum, expansa. Antheræ haud aristatæ.

Species hujus sectionis adhuc unica (*L. fatua* Becc.) cognita, habitat in Indo-China. Nomen hujus sectionis in honorem Rev. Presb. BON, qui specimen typicum speciei in Tonkinia Occidentale legit.

Sectio 3: **DAMMERA** (Becc.) Furtado **stat. nov.**

Dammera Becc. in Webbia V (1921), 24 et 38 et in Calc. Annals XIII (1933) 116 et 130 (loco subgeneris).

Dammera K. Schum. et Laut, Fl. deutsch Schutzgeb. Sudsee (1900) 201 t. A–F et 2 (loco generis).

Annulus staminalis elevatus, crassus. Filamenta e basi valida superne attenuata et antherarum dorso prolixe adnata. Antheræ haud aristatæ. Species hujus sectionis duæ tantum cognitæ, ambæ in Nova Guinea habitant.

Species typica: **L. Beccariana** Furtado **nom. nov.**

Basinym: *L. ramosa* (K. Schum. et Laut) Becc. (1921), nec *L. ramosa* Bl.

Sectio 4: **BECCARIA** Furtado **sect. nov.**

Annulus staminalis brevis, crassus, conspicuus. Filamenta lobiformia, perlonga, subulata, apice bis inflexa (i.e. apice introflexa et rursus erecta), antheras apiculato-aristatos ferentia.

Species hujus sectionis adhuc unica (*L. reptans* Becc.) cognita in Borneo habitat.

Nomen hujus sectionis in honorem Cl. O. BECCARI, palmographi magni.

III. PERICYCLA (Bl) Drude in Engl. u. Prantl, Pflanzenf. II, 3 (1887) 35 (Sphalmate Pericyla).

Pericycla Bl., Rumphia II (1844) 47 t. 94 (loco generis).

Pericycla (Bl.) Ridl. in Journ. Roy. Asiat. Soc., Straits Settl. 41 (1903) 42, Mat. II (1907) 159 et Flora V (1925) 25—(loco sectionis; sphalmate *Pericyclus*).

Staminum filamenta 6, erecta, valde inæqualia, 3 ad loborum apicum majorum inserta, et 3 in sinubus vel ad loborum apicum minorum sita, ad corollæ faucem in annulum prominentem connata. Antheræ haud aristatæ. Flores inter minores.

Species hujus subgeneris paucæ, omnes in regionibus oceaniis habitant; unica in Australia, alteræ in insulis

papuanesianis usque ad insulas Solomonenses, maximæ in Nova Guinea.

Species typica: *L. penduliflora* (Bl.) Miq. (=*Pericycla penduliflora* Bl.).

4. Analytical Key to the Species

A. Flowers about 15 mm. or more long and 5 mm. or more across. Stamens 6, equal, free at the throat of the corolla, the staminal ring being almost obsolete (LIBERICULA). .. *L. peltata* Roxb.

AA. Flowers about 3–8 mm. long and 2 mm. across. Stamens united at base into a conspicuous ring at the throat of the corolla .. (B).

B. Staminal ring 3–lobed, lobes emarginate; 1 filament in the notch at the apex of each lobe and 1 in each sinus between the lobes. (PERICYCLA).

(*a*) Leaf-blade entire. Partial inflorescences paniculately divided into 8–10 branchlets (spikelets) .. *L. grandis* Wendl. (cultivated).

(*aa*) Leaf-blade multipartite. Partial inflorescences digitately divided into 3–4 branchlets .. *L. Rumphii* Bl. (cultivated).

BB. Staminal annulus ends in 6 almost equal lobes or filaments (EU-LICUALA) .. (1).

1A. Spadix simple, terminated by one or more floriferous spikelets .. .. (2).

1B. Spadix branched into two or more partial inflorescences, each internode sheathed by a separate spathe .. (4).

2A. Spadix terminated by one or two spikelets .. (3).

2B.	Spadix terminated by many floriferous spikelets (sometimes a short liguliform spathe intervening) ..	*L. modesta* Becc. (partly).
3A.	Spadix axis and flower-buds covered with long coarse hairs. Calyx striate, splitting into many longitudinal fibres. Leaf divided into 5–8 segments ..	*L. Kingiana* Becc.
3B.	Spadix axis and flower-buds covered with minute hairs, Calyx membranous, not dissolving into fibres. Leaf segments 12–15 ..	*L. Scortechinii* Becc.
4A.	Partial inflorescences unbranched (*i.e.* consisting of solitary spikelets) ..	(5).
4B.	Partial inflorescences branched	(14).
5A.	Flowers distinctly pedicelled. Calyx turbinate or narrowed into a long pedicelliform base	(6).
5B.	Flowers not distinctly pedicelled. Calyx cylindrical or campanulate ..	(8).
6A.	Spikelets distinctly hairy. Calyx hairy, or, if deciduously hairy, the corolla is distinctly hairy	(7),
6B.	Spikelets and calyx not hairy, but covered with fugaceous rusty-brown scales. Corolla glabrous	*L. Moyseyi* Furtado
7A.	Hairs on spikelets and calyx long, coarse. Calyx nearly as broad as long, membranous, striate, turbinato-campanulate, suddenly ending in a short solid cylindrical base, more or less lobed at apex. Flowers usually solitary ..	*L. Kunstleri* Becc.
7B.	Hairs on spikelets and calyx fine. Calyx coriaceous, not striate, cup-shaped, nar-	

	rowed into a long (longer than the cup) pedicelliform base, obscurely denticulate at apex but not lobed or lacerate. Flowers in groups of 2–3 in some parts	*L. Corneri* Furtado
8A.	Calyx cyathiform-campanulate, deeply lobed ..	(9).
8B.	Calyx cylindrical, truncate or lobed at apex ..	(11).
9A.	Calyx covered with long coarse hairs, usually one carpel fertile. The lateral margins of leaflets nearly straight	(10).
9B.	Calyx covered with fine hairs which later fall off partly. Frequently two or three carpels fertile. Lateral margins of leaflets arched, so that leaflets are arcuately cuneate	*L. kemamanensis* Furtado.
10A.	Hairs tawny	*L. acutifida* Mart. (partly).
10B.	Hairs whitish	*L. pusilla* Becc. (partly).
11A.	Calyx ±4 mm. long, densely tomentose, curvately cuneate at base, little lobed at apex	*L. tiomanensis* Furtado.
11B.	Calyx smaller, puberulous or glabrous, not curvately cuneate at base; truncate or deeply lobed at apex ..	(12).
12A.	Calyx conspicuously striate, glabrous, asymetrically lobed at apex, truncate, caudiculate at base ..	*L. pahangensis* Furtado.
12B.	Calyx puberulous or glabrous, but neither conspicuously striate nor caudiculate ..	(13).
13A.	Calyx apex almost truncate at first, then irregularly split	*L. Ridleyana* Becc.
13B.	Calyx deeply lobed ..	*L. confusa* Furtado.

14A.	Lower partial inflorescences paniculiform, composed of 10 or more scattered spikelets (=floriferous branchlets)	(15).
14B.	Lower partial inflorescences composed of 2–5, usually digitate, spikelets ..	(17).
15A.	Spikelets slender, somewhat flexuose. Flowers frequently in groups of 2, spirally, or in terminal parts subalternately, arranged. Calyx 5 mm. long, about twice as long as it is broad ..	*L. longicalycata* Furtado.
15B.	Spikelets stouter, not flexuose. Flowers pluriseriate, usually solitary. Calyx shorter, almost as long as broad	(16).
16A.	The spathes much inflated. Spadix flexuose. Calyx cylindrical, thick from the very beginning. Ovary villous in the upper part ..	*L. longipes* Griff.
16B.	Spathes not so inflated. Spadix not flexuose. Calyx campanulate, membranous at first. Ovary glabrous ..	*L. paludosa* Griff.
17A.	Calyx glabrous, not split or lobate, but denticulate at apex	(18).
17B.	Calyx otherwise ..	(19).
18A.	Leaf-lamina about 12″–16″ in radius, divided into 12 or more, triangular, subequal segments	*L. glabra*
18B.	Leaf-lamina 8″–12″ in radius, divided into 5–8, arcuately cuneate, unequal segments, median segment divided half-way	*L. glabra* var. *selangorensis.*
19A.	Flowers pedicellate ..	*L. mirabilis.*
19B.	Flowers not pedicellate ..	(20).

20A.	Spathes and spadix densely covered with dark fuscous ferruginous scurf, and the spikelets and calyces densely covered with similarly coloured hairs ..	*L. ferruginea.*
20B.	Scurf and hairs when present not similarly coloured and frequently not so thick ..	(21).
21A.	Calyx cylindric, truncate at first, slightly split later. Spadix and spikelets not covered with a thick coat of deciduous tomentum ..	*L. malajana* Becc.
21B.	Calyx campanulate, lobed, or, if apparently truncate in early phases, the spadix and spikelets covered with a thick coat of deciduous tomentum	(22).
22A.	Plants stemless, about 12″–18″ long, smallest in the genus. Leaves the smallest in the genus, divided into 3–8, rarely more, segments. Spadix about 12″–15″ long, with spikelets 1½″–2½″ long ..	(23).
22B.	Plants and leaves larger, with more leaf segments. Spadix and spikelets usually longer	(24).
23A.	Flowers frequently in groups of 2–3, often more than one fertile carpel. Fruit narrow elongate, about 3–4 times as long as it is thick. Ovary glabrous. Median leaf-segment never petiolulate	*L. Kiahii* Furtado.
23B.	Flowers solitary, with only one fertile carpel. Fruit globose. Ovary hairy. Median segment frequently petiolulate	*L. triphylla* Griff.

24A. Lower partial inflorescences usually bifid, the upper ones unbranched. Most of the leaflets nearly linear, about ¾″–1½ inches in width (25).

24B. Lower partial inflorescences usually 3–5–branched. Leaflets in most cases broader and conspicuously triangular .. (26).

25A. Spikelets and calyces rusty-tomentose. Flowers pluriseriate on a cylindrical spikelet .. .. *L. acutifida* Mart. (partly).

25B. Spikelets and calyces whitish-tomentose. Flowers arranged spirally on flexuose spikelets .. .. *L. pusilla* Becc. (partly).

26A. Spadix, spathes and spikelets covered in early stages with a thick coat of creamish deciduous woolly tomentum. Corolla densely sericeous. Flowers solitary *L. lanuginosa* Ridl.

26B. Tomentum, when present on spadix, spathes or spikelets, not thick, and minute. Flowers frequently in groups of 2–3, Corolla glabrous or minutely hairy (27).

27A. Leaflets about 12″ long. Spadix at the most 2½ ft. long. Spikelets usually less than 6″ long and the lower spadix branches about 6″ or less apart. Fruit elliptic, about 10–13 mm. long, 6–8 mm. through .. *L. modesta* Becc. (partly).

27B. Leaflets 20″ or more long. Spadix 6 ft. or more long, with lower branches 9–18 inches apart, each spikelet in lower branches being 9–15″ long. Fruit globose, 6–8 mm. in diameter .. *L. spinosa* Wurmb.

5. Systematic Notes

A. LIBERICULA Furtado.

Licuala peltata Roxb., Fl. Ind. II (1824) 179; Griff. in Calc. Journ. Nat. Hist. V (1845) 324, et Palms Brit. Ind. (1850) 120 t. 222; Hook. f., Fl. Brit. Ind. VI (1892) 430; Becc. in Webbia V (1921) 24 et 39, et in Calc. Annals XIII (1933) 131 t. 74.

MALAY PENINSULA: *Lower Siam,* Kantang (Haniff & Nur, 4720).

Distribution: In the monsoon forests of North East India, Burma, Andamans and Nicobars.

This species was not recorded previously in the Peninsula, where it occurs only in the northern-most parts which form the southern-most range of the distribution of the species. In cultivation it is grown in many gardens throughout the Peninsula. The species sometimes begins to flower before its leaves have started to divide into segments.

B. EU-LICUALA § *Wurmbia* Furtado.

1. **Licuala acutifida** Mart., Hist. Nat. Palm. III, ed. 1 (1842) 237, t. 135 III et IV; Griff. in Calc. Journ. Nat. Hist. V (1845) 237 et Palms Brit. Ind. (1850) 122 t. 222 A et B; Mart. op. cit. III, ed. 2 (1849) 236 et (1850) 318; Hook. f., Fl. Brit. Ind. VI (1892) 433; Ridl., Mat. II (1907) 163 pp.; Becc. in Webbia V (1921) 30 et 44; Ridl., Flora V (1925) 27 pp.; Becc. in Calc. Annals XIII (1933) 168.

MALAY PENINSULA: *Penang,* Tulloh Bahang (Curtis, 1010); Government Hill (Ridley and Curtis, 7906); Waterfall (Curtis in June 1890); Penang Hill (Ridley in July 1898).

This species is very near to *L. Kunstleri* and so far not known from outside Penang. RIDLEY referred here some specimens of *L. pusilla* Becc. LOBB 280 cited by BECCARI as from Singapore may have come from Penang, for LOBB frequently gave incorrect localities to his plants, and there are reasons to believe that the majority of the Malayan plants collected by LOBB were from Penang (*vide,* BURKILL, in *Gard. Bull. Straits Settl.* IV, 1927 p. 127).

CURTIS notes on his specimen numbered 1010 that this is not the palm that supplies the walking sticks known as the "Penang Lawyer".

2. **Licuala confusa** Furtado **sp. nov.** Fig. 1.

? *L. acutifida* Becc. var. *peninsularis* Becc. in Webbia V (1921) 30 et 44, et in Calc. Annals XIII (1933) 169 t. 10–II. *Syn. nov.*?

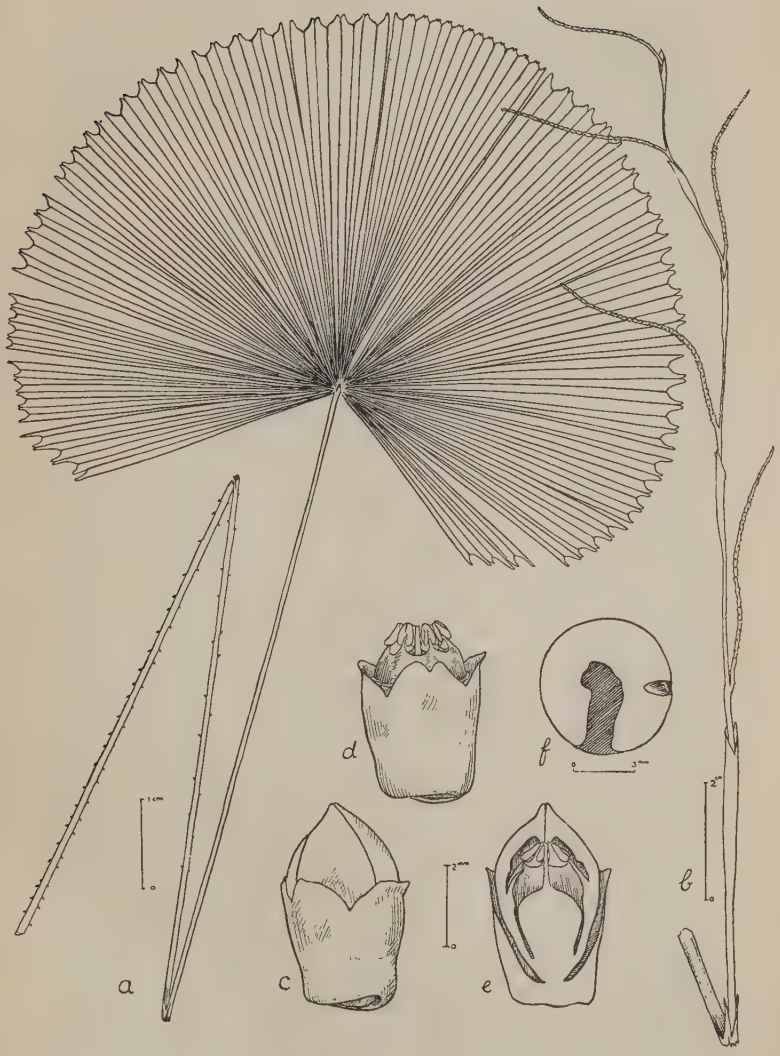


Fig. 1. Licuala confusa (Holotypus: FURTADO no. A).

a. Frons. **b.** Spadix. **c.** Alabastrum. **d.** Alabastrum, petala resecta, ut aestivatio staminum appareat. **e.** Alabastrum verticaliter discissum. **f.** Semen verticaliter discissum.

A L. Ridleyana, *cui valde affinis, differt calyce conspicue lobato, apice nonnihil membranaceo.*

Palma solitaria, acaulescens. *Petiolus* ultra 1 m. longus, interdum minor, ad medium aculeatus. *Segmenta* foliorum circa 17, subaequalia vel inaequalia, 2–4 costata, 34–45 cm. longa; medianum indivisum, interdum alteris multo latius, 6–12 costatum. *Spadix* petiolo brevior, in 4–5 partiales inflorescentias simplices, axi tomentosas divisus. *Flores* pluriseriatim dispositi, solitarii, plerumque super pulvinos prominulos interdum in depressionibus inserti. *Calyx* puberulus, cylindricus, basi truncatus, apice 3-lobatus, lobis rotundatis, saepe in 2 lobulos fissis, parum striatis, nonnihil membranaceis. *Corolla* calyce duplo longior, lobis acutis, puberulis vel non. *Annulus* staminalis in 6 filamenta antherifera abrupte subulata divisus. *Ovarium* glabrum. *Fructus* vivo rubrus, in sicco brunnescens, rugosus, circa 8 mm. in diam.; semen orbiculare 5 mm. in diam., gramineum, fossa integumentale cylindrica, ad centrum seminis cursa, apice parum curvata.

MALAY PENINSULA: *Perak,* Tapah Hill (Furtado sub litt. A, 11 June 1937–Holotypus); Tapah (Ridley, 14112); Bujong Malacca (Curtis in Dec. 1895 et in Aug. 1898). *Dindings,* Lumut (Ridley in Feb. 1892). *Selangor,* Semenyih (Hume, 7962).

RIDLEY 14112 is the haptoholotype of *L. Ridleyana* and in the capsules mounted on the sheet there are a few flowers which agree with the description and figure given by BECCARI for that species. But the vast majority of the flowers in the capsule and the flowers still attached to the spikelets are like the ones described here. Since I have typified *L. Ridleyana* on the characters of the flowers, I could not retain under that species RIDLEY 14112 from the Singapore herbarium. There are some minor variations between RIDLEY 14112 and the holotype of *L. confusa.* The Dindings specimens has no flowers and has been cited here because of its general resemblance to this species.

I have reduced here *L. acutifida* var *peninsularis* with some doubt. RIDLEY 9806 is cited as a paratype of the variety, but its duplicate in Singapore is *L. Ridleyana* as typified here. I have not been able to find in the Singapore herbarium any material which agrees exactly with the figures by BECCARI. RIDLEY 10329 from Lumut (the type collection is cited as 10239) bears calyces somewhat similar to the ones figured by BECCARI, but the partial inflorescences are branched in the Singapore specimen and the corolla is hairy. It seems to represent a variety of *L. spinosa,* typical material of which species is also mounted on the same sheet.

L. confusa has manifest affinities with *L. Ridleyana* but this has a truncate calyx which later splits irregularly. *L. pahangensis*, also an ally of *L. confusa*, has a glabrous, conspicuously striate calyx which bears a somewhat caudiculate base and less symmetrical lobes at the apex.

3. Licuala Corneri Furtado **sp. nov.** Fig. 2.

L. Kunstleri *proxima, a qua calycibus basin versus pedicelliformiter longe productis truncatis, obscure denticulatis, sat distincta.*

Palma solitaria ut videtur, cum caule 0·60–2 m. longo, 2–4 m. alta. *Petiolus* 35–100 cm. longus, prope basin tantum aculeatus, in medio circa 6–8 mm. et apice 4 mm. latus. *Segmenta* frondium subaequalia, circa 12–14, cuneatissima, 2–3, raro 1–4, costata, 25–35 cm. longa, apice 3–4·5 cm. lata; mediana alteris latiora, apice dentibus brevissimis. *Spadices* compositi, 35–80 cm. longi, in dimidia parte basali haud ramosi, cum 2–3 spathis involuti, in altera parte terminali in ramos simplices, florigeros, plerumque 3–4, ad 15 cm. usque longos, dense pubescentes, divisi. *Spathae* basales bicarinatae, alterae tubulares, punctis fugaceo fusco-leprosis tectae, apice marcescentes. *Flores* geminati vel interdum solitarii, pedicellati, in alabastro fusiformes, 5–8 mm. longi. *Calyx* dense pilosus, 4 mm. longus, apice truncatus, obscure 3–denticulatus, in basin pedicelliformen contractus. *Corolla* calyce cupulari duplo longior, glabra. *Annulus* staminalis in filamenta 6 apice abrupte contracta, divisus. *Fructus* immaturus tantum visus, ellipticus, utrinque acutus, circa 6 mm. longus, 4–5 mm. in diam., fossa albuminali indivisa, cylindrica.

MALAY PENINSULA: *Kemaman,* Ulu Bendong in Kajang, alt. 500 ped. (Corner, 30072–Holotypus); Sungai Nipa (Corner, s.n.).

CORNER 30072 was found mixed with some specimens of *L. malajana.* The collector notes: palm is slender solitary; leaflets dark green above, pale beneath, not glaucous; flowers greenish white; fruit fall orange-red when ripe; perianth green; staminal tube white; ovary pale orange; inflorescence hanging".

Though this species falls into the group having simple partial inflorescences, it has no close ally in the Peninsula except the one described here as *L. Moyseyi.* In the long pedicelliform base of the calyx and its obscurely toothed apex the species may seem to appear very near to *L. Beccariana* of New Guinea but that species has been described to have very much longer flowers borne on simple and shorter spadices and belongs to the section DAMMERA.

4. Licuala ferruginea Becc. in Hook. f., Fl. Brit. Ind. VI (1892) 432; Ridl., Mat. II (1907) 162; Becc.

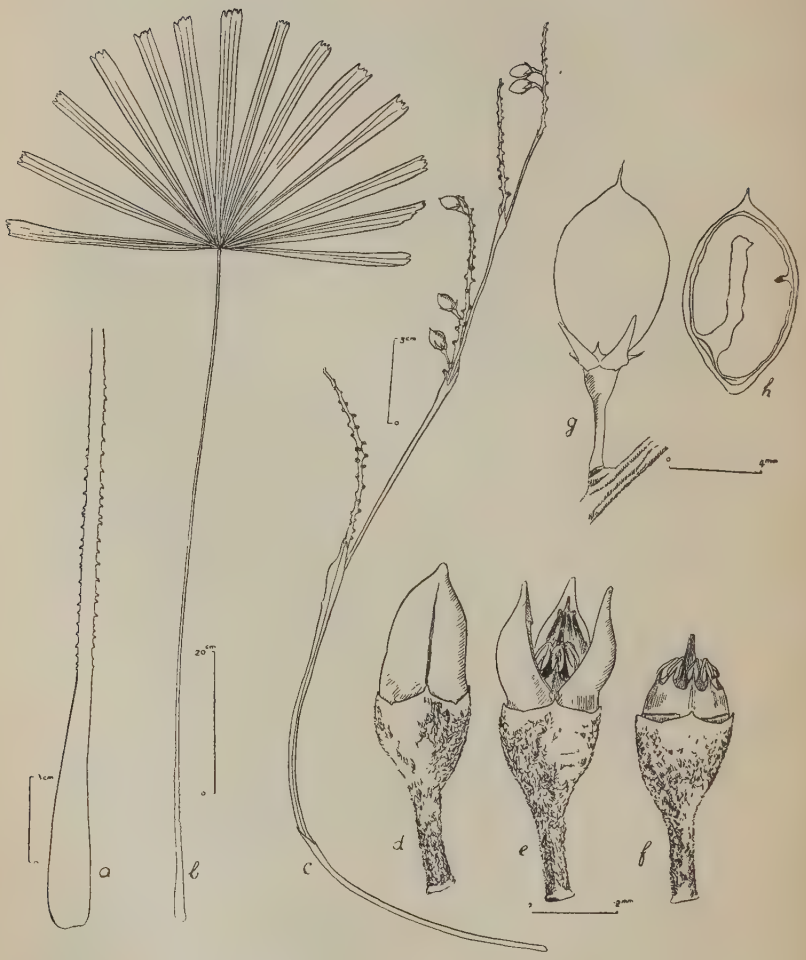


Fig. 2. Licuala Corneri (Holotypus: CORNER 30072).

a. Petioli pars inferior. **b.** Frondis lamina cum petiolo. **c.** Spadix fructiferus minimus. **d.** Alabastrum. **e.** Flos ad anthesin. **f.** Flos, corolla resecta, ut aestivatio staminum appareat. **g.** Fructus cum perianthio et filamentis staminum. **h.** Fructus verticaliter discissus, semen cum substantia integumentale oblique percurrente et embryone dorsale exhibens.

in Webbia V (1921) 32 et 46; Ridl., Flora V (1925) 26; Becc. in Calc. Annals XIII (1933) 180 tt. 9–X, 89 et 89 bis.

MALAY PENINSULA: *Kemaman* Bukit Kajang, alt. 1,000 ft. (Corner, 30398). *Pahang,* Pulau Tawar (Ridley in 1891); Bukit Sagu (Nur, 25167). *Negri Sembilan,* Ayer Kuning near Bahau (Symington, 24380). *Johore,* Sednah (Ridley, 13519); Sungai Kayu Ara (Corner, 28688); Mount Austen (Ridley in Jan. 1904); Kluang (Holttum, 9260); Gunong Belumut (Holttum, 10605); Sungai Endau (Holttum, 24944). *Singapore,* Reservoir Woods (Ridley in 1893); Bukit Timah (Ridley, 3512); Sungai Jurong (Mat in 1894); Ang Mo Kio (Ridley, 6676); Bukit Mandai (Ridley s.n.); Bukit Arang (Goodenough on 16 Nov. 1889); Botanic Gardens' Jungle (Ridley, 3168).

Distribution: Sumatra and Riow Archipelago.

From all the peninsular species having branched partial inflorescences this species is easily distinguished by the presence of the ferrugineous tomentum on spikelets and calyx and by the sessile flowers. It is distinguished from the Sumatran *L. ferruginoides* (which frequently produces branched partial inflorescences) by longer hairs on the calyx and smaller flowers.

5. **Licuala glabra** Griff. in Calc. Journ. Nat. Hist. V (1845) 329 et Palms Brit. Ind. (1850) 124 t. 233; Hook. f., Fl. Brit. Ind. VI (1892) 432; Ridl., Mat. II (1907) 161; Becc. in Webbia V (1921) 34 et 48; Ridl., Flora V (1925) 26; Becc. in Calc. Annals XIII (1933) 192 tt. 14–I fig. 1–3, et t. 82.

L. longepedunculata Ridl. in Journ. Roy. Asiat. Soc. Straits Br. XLI (1903) 42, Mat. II (1907) 161 et Flora V (1925) 26.

MALAY PENINSULA: *Peninsular Siam,* Kampong Bukit (Kiah, 24256). *Kelantan,* Kuala Betis (Henderson, 29725). *Perak,* Gunong Batu Puteh (Wray, 254–Syntype of *L. longepedunculata*). *Pahang,* Karak (Best, 13884); Gunong Tahan (Haniff & Nur, 8111); Fraser Hill (Burkill & Holttum, 7842); Tahan Woods (Ridley, in 1891). *Malacca,* Gunong Ledang (Ridley, 3473); Mount Ophir (Feilding in 1892; Derry, 633; Hullett, 852; Ridley in Dec. 1899). *Selangor,* Bukit Hitam (Kelsall in 1890; Ridley in May 1896); Bukit Kutu (Ridley 7894).

In this species there is a good deal of variation in size and robustness of the leaves, spadices, and flowers, and I agree with BECCARI in reducing *L. longepedunculata* to *L. glabra,* though the former has somewhat larger flowers than

the type of the latter. The specimen from Peninsular Siam has a somewhat pedicelliform base to the calyx, but transitions from this to the typical form are also found.

6. **Licuala glabra** Griff. var **selangorensis** Becc. in Webbia V (1921) 35 et 48; Ridl., Flora V (1925) 26; Becc. in Calc. Annals XIII (1933) 194 t. 14–I.

MALAY PENINSULA: *Trengganu,* Gunong Padang alt. circ. 2,500 ft. (Moysey & Kiah, 33399). *Pahang,* Fraser Hill, alt. 4,000–4,300 ft. (Burkill & Holttum, 8426). *Selangor,* Semangkok Pass, up to alt. circ. 3,000 ft. (Ridley in Aug. 1904; 15881, et 12117: Haptoholotype); Sempang (Ridley in April 1911). *Johore,* Kluang (Holttum, 10601).

The Trengganu specimen cited above is a more robust form than the others.

7. **Licuala kemamanensis** Furtado **sp. nov.** Fig. 3.

A L. ferruginoidea, *cui peraffinis, palma acaulescente, frondibus minoribus, spadicibus haud flexuosis, ramis supra spathae apicem remote orientibus, floribus minoribus, bracteolis inconspicuis recedit. Facie* L. Kunstleri *similis, sed floribus haud conspicue pedicellati, calyce basin versus haud valde angustato, ovariis pilosis, foliis minoribus dissimilis.*

Palma humilis, acaulescens. Petiolus circa 30–65 cm. longus in specimina visa, tertia parte basali aculeis remotis brevibus, 1–2·5 mm. longis armatus. *Segmenta* foliorum circa 14, cuneatissima, 2–6 costata, subaequalia; medianum circa 27 cm. longum, 4 cm. latum, 3–6 costatum, apice obsolete dentatum costis approximatis; intermedia mediano aequilata vel fere, paulo breviora, oblique eroso-dentata, costis 3–4 nonnihil remotis; basilaria minima, 2–3 costata, 12–14 cm. longa, 2·5–3 cm. lata, apice intermediis conformia. *Spadix* unicus tantum visus, haud flexuosus, 60 cm. longus, in inflorescentias partiales duas simplices, 5–8 cm. longas, ferrugineo tomentosas, supra spathae apicem remoto orientes divisus, basi cum spathis 3 involutus. *Spathae* fugaceo fusco-furfuraceae, tubulosae, infima bicarinata. *Flores* pluseriatim dispositi, solitarii, in alabastro globoso-ovati, circa 4 mm. longi; super pulvinum prominentem basi bracteolatum siti. *Calyx* lato campanulatus, ferrugineo-pilosus, haud striatus, ad medium in lobos 3 rotundatos divisus, basi truncatus. *Corolla* calyce duplo longior, striata, apice acuta, puberula. *Annulus* staminalis in filamenta 6 aequalia abrupte subulata divisus. *Ovarium* loculis saepe 3 fertilibus praeditum, minute pubescens.

MALAY PENINSULA: *Kemaman,* Sungai Nipa (Corner, 30520).

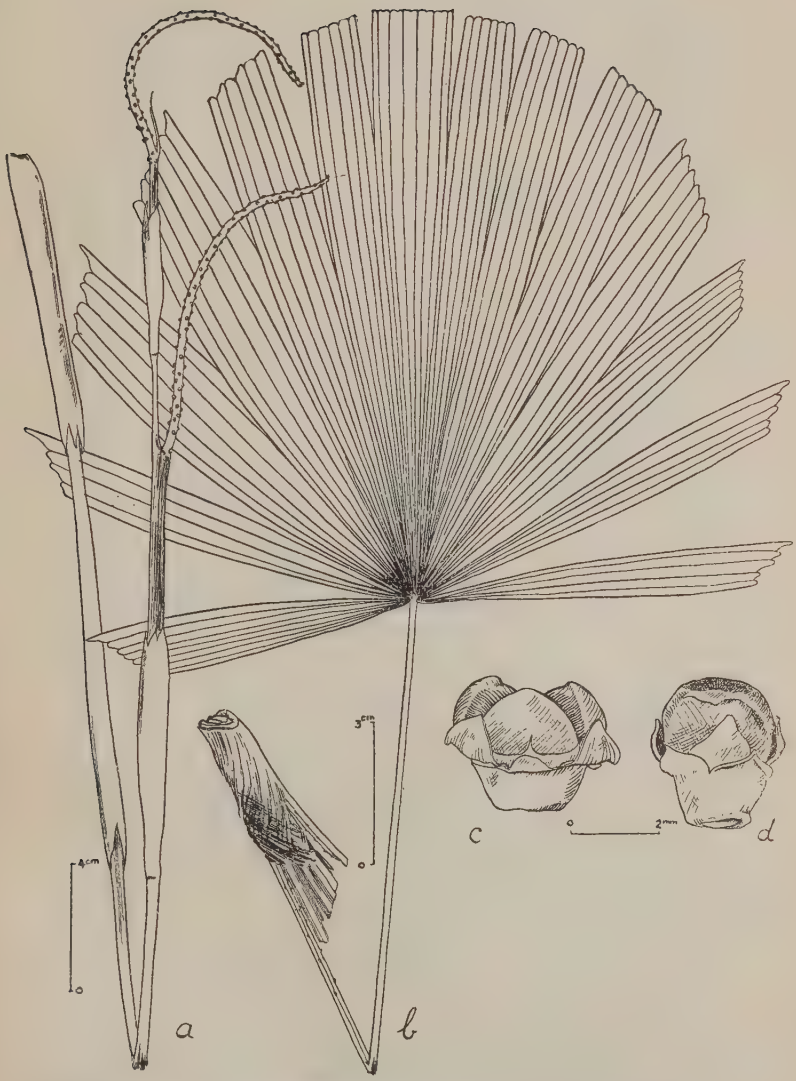


Fig. 3. Licuala kemamanensis (Holotypus: CORNER 30520).
a. Spadix. **b.** Frons. **c.** Flos tres carpella fertilia et unum filamentum staminale exhibens. **d.** Flos cum uno carpello fertile.

This species appears to be very near to *L. ferruginoides*, a Sumatran species described to have simple partial inflorescences but known also to bear sometimes two spikelets to each spadix branch. *L. ferruginoides* is however a very tall species having much larger leaves and flowers, a zigzag axis to the spadices, the spikelets arising a little below the apex of the leaves.

The only peninsular species having simple partial inflorescences to simulate *L. kemamanensis* is *L. Kunstleri*, but the latter is readily distinguished from the former by the very long pedicels of its flowers, turbinate calyx, and glabrous ovary.

8. **Licuala Kiahii** Furtado **sp. nov.** Fig. 4.

Palma humilis acaulescens. *Petiolus* 60–70 cm. longus, praesertim ad basin versus rubescens, prope basin tantum spinis reduncis, remotis, 1–2 mm. longis armatus. *Segmenta* foliorum 5, rarissime 6–7, inaequalia; medianum 10–14 costatum, 20–25 cm. longum, apice 8–10 cm. latum, superficialiter obtuseque dentatum, cuneatissimum, sessile; altera 3–5 costata, mediano minora, oblique eroso-truncata, arcuato cuneata. *Spadix* petiolo duplo vel triplo brevior, basi cum pedunculo circa 20 cm. longo fusco-furfuraceo, spathis 3–4 tubulosis induto, suffultus, apice in inflorescentias partiales 2–3, simplices vel bifurcatas, furfuraceas, 3–4.5 cm. longas divisus. *Flores* in glomerulis 1–3, remotis, alterne vel spiraliter dispositi, sessiles, pulvino inconspicuo. *Calyx* furfuraceus, pubescens, in lobos acuminatos profunde partitus.*Corolla* calyce parum longior, pubescens, in lobos altos, acuminatos divisa. *Annulus* staminalis in sex filamenta abrupte subulata divisus. *Ovarium* glabrum; carpellis plerumque 1–2 vel saepius omnia evolutis. *Fructus* elongato-clavatus, saepe parum curvatus, circa 22–23 mm. longus, 3·5–4·5 mm. in diametro; semine conforme, osseo; fossa integumentali embryo dorsali supra basin objecta, apicem versus mox ascedente cylindracea.

Malay Peninsula: *Johore*, in collibus apud ripas Sungai Kayu (Kiah, 32137, Holotypus); in monte Gunong Pulai (Haniff, s.n., 27 Dec. 1925).

This species is very peculiar in the genus in that it has very long fruits borne on a compound spadix. The only other species known to produce such long fruits is *L. mattanensis* Becc. from Borneo, which however is characterised by many-lobed leaves, a simple, unbranched spadix having almost pedicellate flowers, and the integumental process in the seed situated on the same side as the embryo (not opposite the embryo as is the case with *L.*

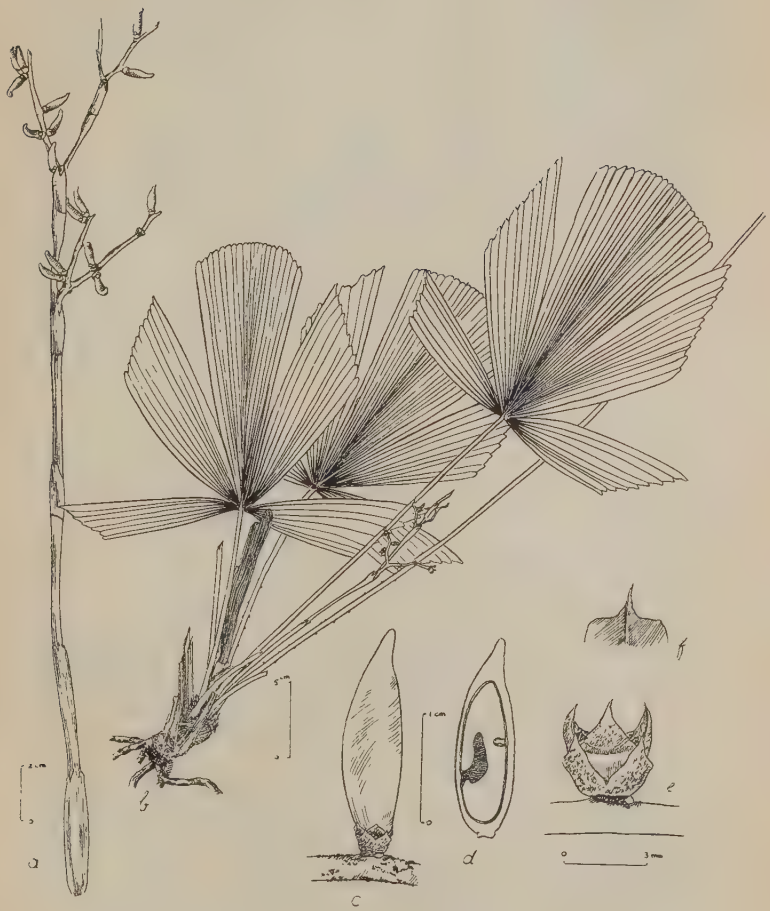


Fig. 4. Licuala Kiahii (Holotypus: KIAH 32127).

a. Spadix. **b.** Planta cum spadice fructifero. **c.** Fructus. **d.** Fructus verticaliter discissus. **e.** Perianthium fructiferum. **f.** Filamentum staminale.

Kiahii). Otherwise *L. Kiahii* has many characters similar to those of *L. mattanensis*, even in the habit of developing frequently more than one fertile carpel in each ovary.

9. **Licuala Kingiana** Becc. in Malesia III (1889) 193; Hook. f., Fl. Brit. Ind. VI (1892) 434; Ridl., Mat. II (1907) 165; Becc. in Webbia V (1921) 38 et 51; Ridl., Flora V (1925) 30; Becc. in Calc. Annals XIII (1933) 213 t. 11–II.

MALAY PENINSULA: *Perak*, Bukit Kapayang (Ridley in Feb. 1904); Sungai Siput (Haniff & Nur, 6962); Gunong Keledang (Ridley, 9804); Kinta Valley (Ridley s.n.); Bujong Malacca (Curtis, 3162); Keledang Saiong (Symington, Cf. 25724 & 25612–Herb. Kepong).

The Bukit Kapayang specimen collected by RIDLEY has one spadix bifid at the apex.

10. **Licuala Kunstleri** Becc. in Hook. f., Flor. Brit. Ind. VI (1892) 433; Ridl., Mat. II (1907) 162; Becc. in Webbia V (1921) 30 et 44; Ridl., Flora V (1925) 27; Becc. in Calc. Annals XIII (1933) 167 t. 94.

MALAY PENINSULA: *Perak*, Temango (Ridley, 14709). *Pahang*, Tanjong Antan (Ridley in 1891); Sungai Lepar (Burkill & Haniff, 17460). *Selangor*, Ulu Gombak, alt. 1,500 ft. (Hume, 9437); Bukit Kutu (Casdani in 1899); Kuala Lumpur (Ridley in 1889); Gua Batu (Ridley in Dec. 1896).

Some specimens of this species have been distributed from Singapore under the name of *L. ferruginea*.

11. **Licuala lanuginosa** Ridl. in Journ. Roy. Asiat. Soc. Straits Br. 44 (1905) 203, Mat. II (1907) 165; Becc. in Webbia V (1921) 33 et 46; Ridl., Flora V (1925) 30; Becc. in Calc. Annals XIII (1933) 181 tt. 9–IV et 50.

L. longipes sensu Ridl. op. cit. (1907 and 1925) pro parte.

MALAY PENINSULA: *Johore*, Gunong Panti (Ridley in Dec. 1892; Corner 30739 & 30739A); Gunong Belumut, alt. 2,200 ft. (Holttum, 10792); Gunong Pulai (Mat in 1892; Ridley 12198 partim; Best 7711; Corner in 1937); Bukit Tinjau Laut alt. 1240 ft. (Corner 37068).

12. **Licuala longicalycata** Furtado **sp. nov.** Fig. 5.

L. bacularię *affinis ut videtur, sed planta robustiore, foliorum segmentis latioribus, inflorescentię ramulis partialis pluribus, floribus majoribus, calyce floris longe piloso, sed fructus interdum laevi, corolla minute pubescente haec species sat distincta. Inter species malayanas* L. glabra *producit formas aspectu calycale similes* L. longicalycatæ,

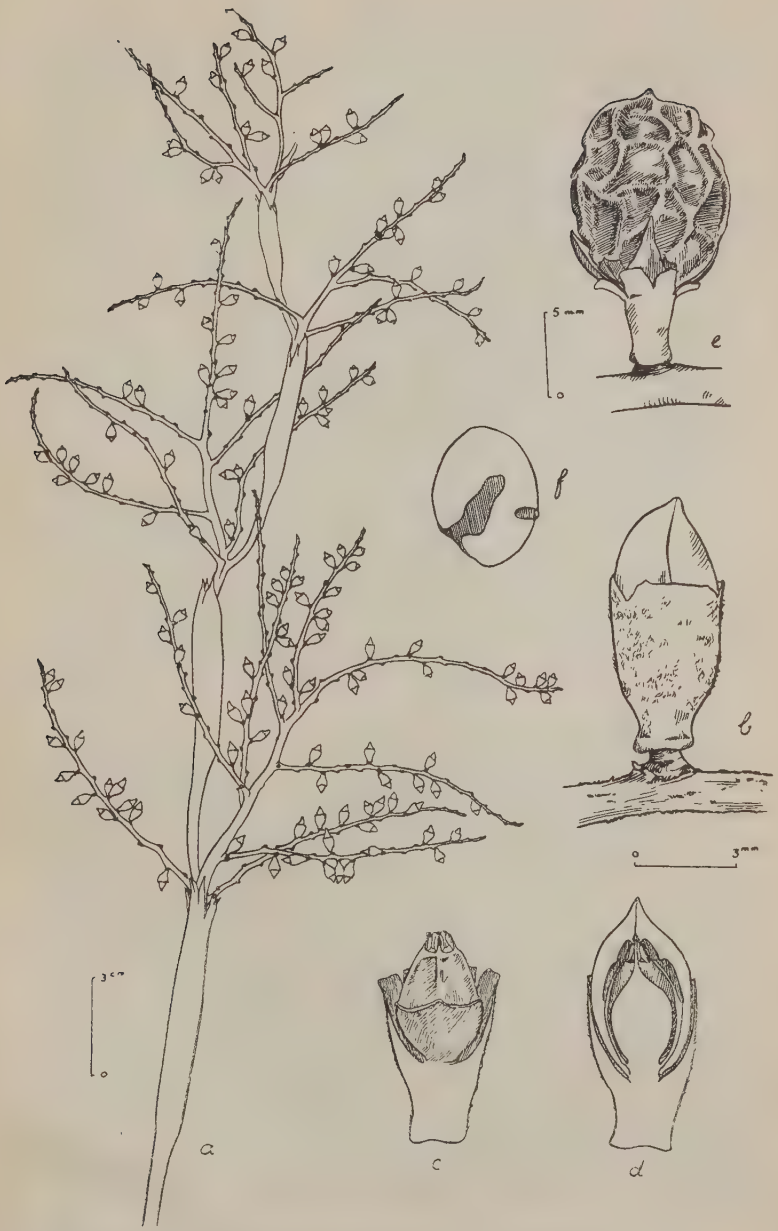


Fig. 5. Licuala longicalycata (Holotypus: KIAH 32401).

a. Pars spadicis floridi. **b.** Alabastrum. **c.** Alabastrum verticaliter discissum ut aestivatio staminum appareat. **d.** Alabastrum verticaliter discissum ut ovarium exhibeat. **e.** Fructus (e specimine SYMINGTON 47092). **f.** Semen ejusdem fructus verticaliter discissum.

a qua illa inflorescentiæ ramulis partialis paucioribus, calyce laevi apice arcuato denticulato (haud truncato et irregulariter fisso), pulvinis floriferentibus brevioribus differt.

Caulis robustus, ad 3 m. altus. *Petiolus* longus 1–3 m. longus, tertia parte basilari aculeatus, apice circa 8 mm. latus. *Segmenta* foliorum circa 16, inaequalia, cuneatissima; centrale latissimum, pluricostatum, apice obtuse dentatum, ad 9–16 cm. latum, 40–55 cm. longum; altera angustiora, altius dentata, 3–4 costata. *Spadix* circa 70–80 cm. longus, petiolo brevior, in 4–5 inflorescentias partiales, unasquisque 5–10 ramulosas, fugaceo fusco-furfuraceas ad apicem spathæ vel paulo infra orientes, divisus, axi flexuosus. *Flores* 6–8 mm. longi, super pedicellum prominentem 1–2 glomerulati, remoti, spiraliter dispositi; in alabastro fusiformes, striati, dense fugaceo-furfuracei. *Spathæ* tubulares, fugaceo furfuraceæ, parum inflatæ, apice parce marcescentes, basilares conspicue bicarinatæ. *Calyx* 4–5.5 mm. longus, gramineus, pilis longiusculis remotis praeditus, cyathiformis, basin versus nonnihil angustatus, utrinque truncatus, apice superficialiter 3 lobatus, interdum in fructu irregulariter fissus. *Corolla* minute puberula, calyce sesqui vel duplo longior, segmentis lanceolatis, acutis, striatis, persistentibus. *Annulus* staminalis 6–fidus, lobis abrupte subulatis. *Ovarium* glabrum, gramineum, rarissime loculis fertilibus 2–3. *Fructus* in sicco oblongus, rugosus, circa 12–14 mm. longus, 10 mm. in diam; semen oblongum, 7 mm. longum, 5 mm. crassum; fossa albuminale indivisa, cylindrica.

Malay Peninsula: *Johore,* Sungai Kayu, in locis paludosis (Kiah, 32401, Holotypus); Kluang (Holttum, 9252); Arong (Symington, 47092–Herbarium Kepong); Labis (Symington, 47068–Herbarium Kepong). *Negri Sembilan,* Ayer Kuning, prope Bahau (Symington, 24379).

In Beccari's Key *L. longicalycata* would have to be placed near *L. paludosa* and *L. bintulensis,* from both of which it is readily distinguished by the longer calyx and the longer flower-bearing pulvini. The species also appears to be very near to *L. bacularia* which I know only from description, and which is a much smaller species having narrower leaf-segments, and more branches to the partial inflorescences. The only peninsular species which may be confused with *L. longicalycata* is *L. glabra,* especially those forms which have a longer calyx, but in the latter species the calyx is glabrous, arcuately denticulate and unlobed or unsplit, even when in fruit. The form, the colour and the pubescence of the calyx remind one of *L. modesta* and *L. tiomanensis,* both of which bear undivided partial inflorescences to the spadix. I have described the young flowers

from SYMINGTON 47068 where there is a portion of very young inflorescence mounted together with an older one; the veins and the thick furfur that is present on the flowers in bud disappear when the flowers are developed. The fruits are described from SYMINGTON 47092.

13. **Licuala longipes** Griff. in Calc. Journ. Nat. Hist. V (1845) 330 et Palms Brit. Ind. (1850) 125 tt. 234 A & B; Hook. f., Fl. Brit. Ind. VI (1892) 431; Ridl., Mat. II (1907) 162; Becc. in Webbia V (1921) 28 et 42; Ridl., Flora V (1925) 27; Becc. in Calc. Annals XIII (1933) 155 t. 8–V.

MALAY PENINSULA: *Kemaman,* Ulu Bendong, Kajang, alt. 700 ft. (Corner, 30111). *Pahang,* Titi Bungor in Temerloh (Henderson, 10559); Mentakab (Holttum, 24560). *Negri Sembilan,* Gunong Angsi (Nur, 11571; Ridley, 10121); Tampin (Burkill, 1417); Gunong Tampin (Burkill, 1171; Holttum 9557); Beremban along Sungai Bendol (Furtado, 33125). *Malacca,* Ayer Panas (Goodenough, 1406; Ridley & Goodenough, 1577); Bukit Besar Ophir (Ridley, 10120 & 3474); Selandan (Ridley, 10793); Bukit Tampin (Goodenough, 1962).

Distribution: recorded from Mergui in Lower Burma.

GRIFFITH cites the syntypes of this species thus: "Malacca, solitary in dense forests, Ayer Punnus (Rhim), Goonoong Miring, and Mount Ophir, but not above an elevation of a thousand feet. Tenasserim coast in forests near Lainear to the south of Mergui."

BECCARI found only one syntype in the Calcutta herbarium with no indication as to its locality, and since he had not seen any specimen definitely coming from the Malay Peninsula, he gave Tenasserim as the probable origin of this GRIFFITH'S specimen. However from the description and the drawings given by BECCARI I think the species is common in the Peninsula, especially in the regions where GRIFFITH saw it.

From the notes given by collectors it appears that this species is very common in Malacca and Negri Sembilan; also that though it is easy to find plants in flower, it is rare to find them in fruit. There are a few specimens which have been collected above a height of 1,000 ft., and in some of these the flower-bearing pulvini are quite prominent (*e.g.* BURKILL 1171 and HOLTTUM 9957); but there are transitions between these and the usual forms where the pulvini are nested in depressions.

There is some variation in the dentation of the calyx; some split very early during the development of the flowers and here the lobes are rounded at the apex and are often bifid; in others this lobation is retarded and the calyx looks

almost truncate and later split irregularly as in *L. malajana*, a species which appears to have very close affinities with *L. longipes*.

GRIFFITH records that this species is known to Malays as *Palas Batu*, a name recently recorded also by a Malay collector who notes that the leaves are used for thatching house roofs.

14. Licuala malajana Becc., Malesia III (1889) 197; Hook. f., Fl. Brit. Ind. VI (1892) 431; Ridl., Mat. II (1907) 161 pro parte; Becc. in Webbia V (1921) 35 et 55; Ridl., Flora V (1925) 26 pp.; Becc. in Calc. Annals XIII (1933) 196 tt. 14–IV et 87.

MALAY PENINSULA: *Trengganu*, Brang in Tersat, alt. 2,500 ft. (Kiah & Moysey, 33398). *Kemaman*, Kajang at Ulu Bendang, alt. 500 ft. (Corner, 30072 A); Sungai Nipa (Corner, 30547).

The following specimens have more hairy calyces, but seem to belong here:

Kelantan, Kuala Krai (Haniff & Nur, 10104). *Pahang*, Bukit Senai (Henderson, 19434). *Selangor*, Pahang Track (Ridley in 1897). *Johore*, Gunong Muntahak, alt. 600 ft. (Nur, 19968).

I have not seen any authentic specimens named by BECCARI and so my identification of the species is based entirely on the description and plates given by BECCARI. The specimens doubtfully cited here come very near to some forms of *L. modesta* which however produces very much shorter spadices bearing flowers in groups of two or three on very prominent, almost pedicelliform tubercles. The typical calyx of *L. malajana* has some resemblance to that of *L. Ridleyana*, but the latter species produces unbranched partial inflorescences.

15. Licuala mirabilis Furtado **sp. nov.** Fig. 6.

A L. Kunstleri, *cui peraffinis, spathæ limbo pedicellum axillaris spicæ plerumque valde superante, spathis superne inflatis, spicis (=inflorescentiis partialibus) 2–5 ramulosis haec species sat distincta. Secundum clavem Beccarii analyticam prope* L. bacularíam *ponenda, a qua spadicibus quam petioli valde brevioribus facile distinguitur.*

Palma solitaria vel sobolifera, cum caule 1–1·5 m. longo 3–4 m. alta. *Petiolus* circa 1·5 m. longus, vagina fibrosa mox marcescente decidua præditus, in 2/3 partibus basalibus aculeis reduncis, inferioribus robustis 4 mm. altis, 1–2 mm. crassis, superioribus obscuris armatus. *Segmenta* frondium 20–27, basin versus valde angustata, fere petiolulata, apice 3·5–7 cm. lata, 5–15 mm. profunde dentata, 2–3, raro 4–6, costata; medianum alteris parum majus 3–6

Fig. 6. Licuala mirabilis (Holotypus: FURTADO 33054).
a. Pars spadicis floridi. **b.** Frondis lamina cum parte petioli. **c.** Fructus. **d.** Semen verticaliter discissum. **e.** Alabastrum. **f.** Pulvinus cum flore dua carpella fertilia exhibente. **g.** Filamentum staminale.

costatum, minus profunde dentatum. *Spadices* petiolo multo breviores, ad 45 cm. longi. *Spathæ* fugaceo furfuracæ basi tubulosæ superne subito inflatæ, apice acutæ, in uno latere fissæ, partem pedicellarem spicarum axillarium plerumque superantes. *Inflorescentia partialis* in spiculas 2–5 axi pubescentes divisa, pedicello ad 2·5 cm. longo, infra limbum spathæ axillantis plerumque oriente, saepe quam limbus spathæ minore. *Flores* conspicue pedicellati, geminati vel solitarii. *Calyx* turbinato campanulatus, pubescens, apice membranaceus, lobatus vel partim truncatoides, in basin cylindricam induratam abrupte constrictus. *Corolla* calyce duplo longior, dense sericea. *Annulus* staminalis in filamenta 6, aequalia superne abrupte subulata. *Ovarium* glabrum. *Fructus* globosus, utrinque acutus, 10–12 mm. longus, 6–8 mm. crassus; albumine carneo, albescenti, fossa integumentale cylindrica, vertice paulo dilatata, interdum biapicali.

Malay Peninsula: *Kedah,* Ayer Tĕrjang Valley in Baling (Furtado, 33054–Holotypus); Yan (Ridley in June 1893). *Province Wellesley,* Permatang Bertam? (Ridley in 1895); Bukit Mertajam, alt. circa 450 m. (Burkill, 9021). *Perak,* Bukit Merbau Balong in Kroh (Furtado, 33037).

This species is closely allied to *L. Kunstleri,* but the branching of the partial inflorescences distinguishes them at once, *L. Kunstleri* having always simple branches to the spadices. From *L. ferruginea,* with which *L. mirabilis* has been confused, it is distinguished by the non-marcescent apex of the spathes, the pedicelled flowers and the membranous calyx having an attenuate and constricted base.

16. **Licuala modesta** Becc., Malesia III (1889) 195; Hook. f., Fl. Brit. Ind. VI (1892) 433; Ridl., Mat. II (1907) 163; Becc. in Webbia V (1921) 35 et 48; Ridl., Flora V (1925) 28; Becc. in Calc. Annals XIII (1933) 198 tt. 14–VI et 88.

L. Wrayi Becc. ex Ridl. in Journ. Roy. Asiat. Soc. Straits Br. 82 (1920) 201; Becc. in Webbia V (1921) 37 & 50; Ridl., Flora V (1925) 28; Becc. in Calc. Annals XIII (1933) 210 tt. 13–I et 46. **Syn. nov.**

Malay Peninsula: *Perak,* Taiping Hills (Hervey, in 1889; Ridley, 14721, in Dec. 1902 and in Feb. 1904; Furtado, 37103); Kuala Kangsar (Ridley, 3167); Gunong Hijau (Fox sub Curtis no. 3529; Burkill & Haniff, 12873 & 12589; Anderson, 164 & 171); Tea Gardens (Ridley, 11406 and in Feb. 1891); Maxwell's Hill (Burkill & Haniff, 12948, & 12551; Ridley in June 1893 & Feb. 1892; Curtis, 2077 partim, ex altera parte=*Calamus* sp.); Gunong Pondok, alt. 1,000 ft. (Henderson, 23804); Box Hill, alt. 4,200 ft, (Fox, 163); Larut Hill (Anderson, 177).

I am unable to detect any appreciable differences between the forms described by BECCARI and RIDLEY as *L. Wrayi* and *L. modesta*. The species produces very short inflorescences; in some there may be a few partial inflorescences separated by more or less elongated tubular spathes; in others the number of branches and the size of the spathes are reduced, so that the entire spadix may appear to bear directly the spikelets on its axis, though one or two liguliform spathes about 3–6 cm. in length will indicate the reduction that has taken place in the spathes; and in still others the ligule may be further reduced into small, inconspicuous bracteoles. If the definition of LICUACELLA were accepted, the specimens bearing these small bracteoles could not be kept in the subgenus that includes *L. modesta*, a reason why BECCARI was obliged to erect *L. Wrayi*.

Some of the specimens cited above were referred by RIDLEY (1907 and 1925) to *L. malajana* and to *L. pusilla*.

17. Licuala Moyseyi Furtado **sp. nov.** Fig. 7.

A L. Corneri, *cui valde affinis, recedit haec species: petiolo inermi; segmentis frondium inaequalibus, mediano latissimo; ramulis floriferis furfuraceis, haud pubescentibus; pedicellis fere tuberculiformibus; floribus in spicis inferioribus plerumque 2–3 glomeratis; calyce fugaceo furfuraceo, haud piloso, minore, apice conspicue 3–lobato.*

Petiolus gracilis, inermis, 75–90 cm. longus, ad basin circa 4 mm. latus, apice paulo angustior. *Segmenta* foliorum 8–10 dentibus 5–10 mm. altis; medianum latissimum, 10–14 costatum, 22–25 cm. longum, apice 10–15 cm. latum; altera angustiora, minora, 3–4, raro 2–5 costata; basilaria minima, apice oblique erosa. *Spadices* 60–75 cm. longi; in parte basilari haud ramosa, 35–40 cm. longa, spathis 2–3 involuti; in altera parte in ramos floriferos 3–4, simplices, fusco furfuraceos divisi. *Spathæ* tubulares, fugaceo fusco furfuraceæ, superiores obscure biangulatæ, haud inflatæ, ad 6 mm. crassæ, apice oblique truncatæ; infima latior conspicue biangulata. *Flores* in tuberculis prominentibus insidentes, 1–3 glomerati, 3–4 mm. longi, clavati. *Calyx* fugaceo fusco furfuraceus, conspicue 3–lobatus, in alabastro apice globosus, basin versus pedicelliformiter contractus. *Corolla* juvenilis tantum visa, haud pubescens. *Annulus* staminalis in filamenta aequalia abrupte subulata divisus. *Ovarium* glabrum.

MALAY PENINSULA: *Trengganu*, Gunong Padang, alt. circa 1300 m. (Kiah et Moysey, 31840).

This species may easily be confused with *L. Corneri*, for both have simple, unbranched partial inflorescences and they are the only species in the peninsula having a long pedicelliform base to the calyx. However *L. Moyseyi* can

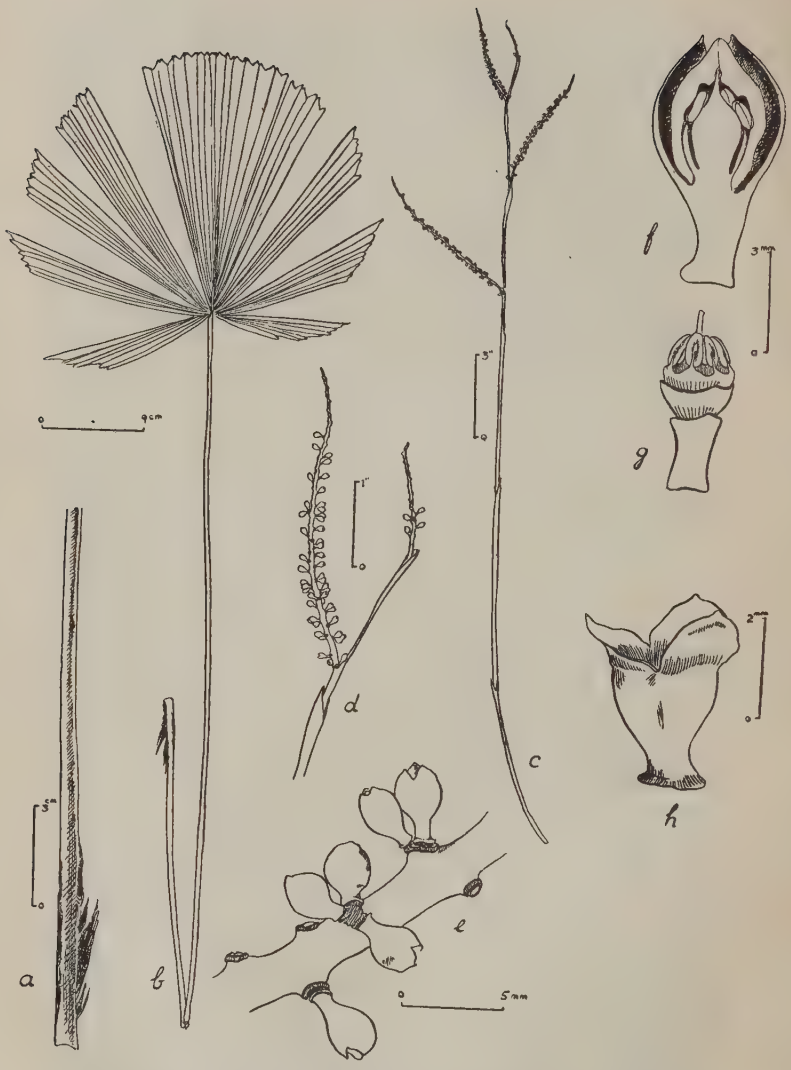


Fig. 7. Licuala Moyseyi (Holotypus: KIAH & MOYSEY 31840).

a. Petioli pars inferior. **b.** Frondis lamina cum petiolo. **c.** Spadix. **d.** Pars ejusdem apicalis. **e.** Pars spicae ut dispositio florum appareat. **f.** Alabastrum verticaliter discissum. **g.** Alabastrum sine perianthio ut aestivatio staminum appareat. **h.** Calyx fructiferus.

be distinguished from *L. Corneri* by its thornless petiole; unequal leaf-segments, the median being 2–3 times broader than the others; furfuraceous, not hairy spikelets; smaller, almost tubercular flower-pedicels; flower-glomerules consisting frequently of 3 flowers; smaller, not hairy, and distinctly 3–lobes calyx.

The flowers present in the specimen are not fully developed, the reason why the description of the petals is so meagre. One fully developed calyx was found on a spadix from which all fruits had fallen off; this calyx is represented in the drawing to show the depth of the calyx lobes.

18. **Licuala pahangensis** Furtado **sp. nov.** Fig. 8.

L. malajana sensu Ridl., Mat. II (1907) 161 et Flora V (1925) 26 p.p.

L. spinosa sensu Ridl. in Trans. Linn. Soc. Lond. III (1893) 391 p.p.

Inter species sapdice composito ramulis floriferis simplicibus ponenda; L. Ridleyanæ *et* L. peninsulari *valde affinis, sed calycibus striatis, glabris, apice alto lobatis, basi truncatis vertice basali caudiculatis; petalis glabris; sat distincta.*

Petiolus 50–100 cm. longus, tertia parte basali aculeatus. *Segmenta* frondium subaequalia; centralia 4–6 costata, 3·5–5 cm. lata, circa 45 cm. longa, paulo latiora et minus profunde dentata alteris 2–3 costatis paulo brevioribus. *Spadices* petiolis fere aequilongi, vel eis paulo breviores, ramis simplicibus, ad 15–20 cm. longis, supra spathæ apicem remoto orientibus. *Spathæ* tubulosæ, fugaceo furfuraceæ. *Flores* solitarii, pluseriatim dispositi, circa 4–5 mm. longi. *Calyx* membranaceus, valde striatus, glaber, apice in 3 lobos asymmetros divisus interdum irregulariter fissus, basi truncatus vertice caudiculatus. *Corolla* glaber, calyce duplo longior. *Annulus* staminalis in filamenta versus apicem arcuatim angustata divisus. *Ovarium* glabrum, loculis saepe duobus vel tribus fertilibus. *Fructus* maturus ignotus.

Malay Peninsula: *Pahang,* ad radicem montis Gunong Senyum (Henderson, 22305–Holotypus); Titi Bungor, Temerloh (Henderson, 10623); Tanjong Antan (Ridley in 1891); Pulau Chengai (Ridley in 1891).

From the species bearing simple spadix-branches *L. pahangensis* is readily distinguished by the striate, glabrous calyx which is deeply lobed at the apex and truncate at the base, where it has a small tail-like projection. Otherwise this species may be easily confused with *L. peninsularis* and *L. Ridleyana.*

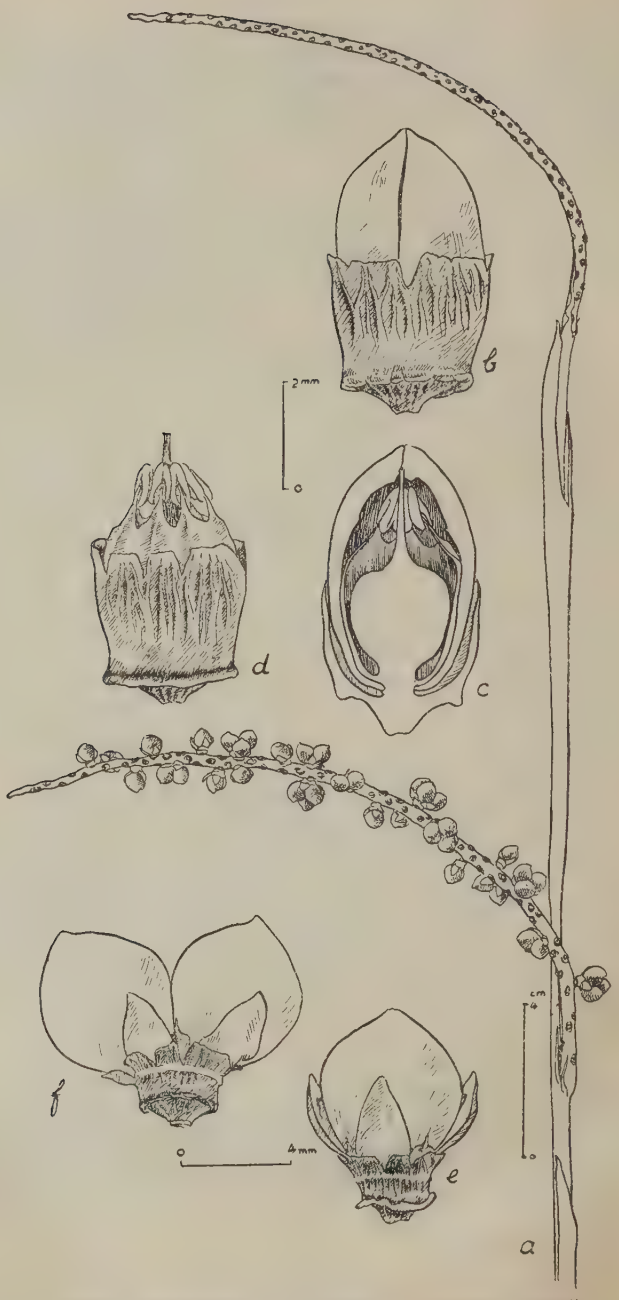


Fig. 8. **Licuala pahangensis** (Holotypus: HENDERSON 22305).

a. Pars spadicis. **b.** Alabastrum. **c.** Alabastrum verticaliter discissum. **d.** Alabastrum, petala resecta, ut aestivatio staminalis appareat. **e.** Fructus immaturus monospermus. **f.** Fructus immaturus dispermus.

19. **Licuala paludosa** Griff. in Calc. Journ. Nat. Hist. V (1843) 233 et Palms Brit. Ind. (1850) 118 tt. 221 A, B, et C; Hook. f., Fl. Brit. Ind. VI (1892) 430; Ridl., Mat. II (1907) 160 p.p.; Becc. in Webbia V (1921) 24 et 43; Ridl., Flora V (1925) 25 p.p.; Becc. in Calc. Annals XIII (1933) 159 tt. 8–XI, et 98.

L. paniculata Ridl. in Journ. Roy. Asiat. Soc. Straits Br. XLI (1903) 42, et Mat. II (1907) 163; Becc. in Webbia V (1921) 29 et 43; Ridl., Flora V (1925) 30; Becc. in Calc. Annals XIII (1933) 161 tt. 10–I et 46. **Syn. nov.**

L. patens Ridl. in Journ. Roy. Asiat. Soc. Straits Br. LXXXII (1920) 202 et Flora V (1925) 25. **Syn. nov.**

L. spinosa sensu Ridl. in Kew Bull. (1926) 91.

MALAY PENINSULA: *Perak,* Hermitage Hill (Ridley in 1892, Holotype of *L. paniculata*); Sungai Krian Estate, alt. sea level (Spare, 33288); Gunong Bubu alt. 4,000 ft. (Wray, 3928, Haptosyntype of *L. patens*). *Selangor,* Sungai Tinggi, near Kuala Selangor (Nur, 34076). *Johore,* Hadji Senawi (Ridley, 11212).

SUMATRA, Siberut in Mentawi Islands (Boden-Kloss, 14614).

Distribution: Borneo and Indo-China.

RIDLEY has referred to this species many specimens of *L. spinosa.* Perhaps he had these specimens in mind when he erected *L. patens.*

L. paludosa is easily distinguished from *L. spinosa* by its calyx being minutely puberulous or almost glabrous outside and irregularly and shortly lobed at the apex. I do not find any important difference between the specimens collected in the lowlands and those collected in the mountains, and so I have reduced *L. patens* to a synonym of *L. paludosa.* There are some small differences noticeable between the types of *L. paniculata* and *L. paludosa,* but there are transitions; but even without these transitions the differences are so trivial that I have no hesitation in reducing *L. paniculata* to *L. paludosa.* (These differences have been noticed by BECCARI in Calcutta Annals *l.c.*).

In erecting *L. paniculata* (1903) RIDLEY remarked that it and *L. penduliflora* from New Guinea were the only species known to him to have a "panicled" inflorescence, which, according to him, characterise the section PERICYCLA. Since he did not include in this section *L. paludosa, L. longipes* and *L. patens,* even in his most recent work (1925), it is not easy to understand RIDLEY'S conception of the section PERICYCLA (sometimes spelt by RIDLEY as *Pericyclus*).

BECCARI has reduced *L. amplifrons* Miq. to *L. paludosa*, but the specimens growing under that name in the Botanic Gardens, Buitenzorg, Java, appear to be different, though BECCARI quoted material from these plants under *L. paludosa*. In 1936 I collected herbarium material from these plants in Buitenzorg and distributed it under the Singapore Field no. 31102 and 31129. The plants can be distinguished from the typical *L. paludosa* in being solitary, bearing shorter petioles, fewer branches to partial inflorescences, longer flower-bearing pulvini, and sometimes the flowers borne in pairs on each pulvinus. The material looks so different that a further inquiry into the status of *L. amplifrons* Miq. seems to be necessary.

20. **Licuala pusilla** Becc., Malesia III (1889) 194; Hook. f., Fl. Brit. Ind. VI (1892) 433; Ridl., Mat. II (1907) 164; Becc. in Webbia V (1921) 31 et 45; Ridl., Flora V (1925) 28; Becc. in Calc. Annals XIII (1933) 174 t. 85.

L. acutifida sensu Ridl. op. cit. (1907) 163 et (1925) 27. p. parte.

MALAY PENINSULA: *Kelantan,* Gua Ninek (Henderson, 19686). *Selangor,* Rantau Panjang (Hume 7619; Ridley in Aug. 1909); Kanching (Foxworthy and Burkill on 30 Nov. 1921). *Negri Sembilan,* Gunong Angsi (Ridley in Feb. 1904). *Malacca,* Sungai Udang (Goodenough, 1360 as Palas Padi).

Of this species I have not seen any specimens named by BECCARI, and so my identification of it is based entirely on BECCARI'S description and plate. The young floriferous branches are covered with whitish tomentum.

This species appears to be very near to *L. triphylla* some forms of which bear many, narrow almost linear segments to the leaves, the median lobe being sessile. Further investigation in the field may prove *L. pusilla* to be only a form or variety of *L. triphylla.*

21. **Licuala Ridleyana** Becc. in Webbia V (1921) 31 et 44 et in Calc. Annals XIII (1933) 170 tt. 10–III et 34.

L. malajana sensu Ridl., Mat. II (1907) 161 et Flora V (1925) 26 p.p.

MALAY PENINSULA: *Perak,* Bujong Malacca (Ridley, 9805, et 9806, Haptoparatype of *L. acutifida* var *peninsularis*).

From the description and drawings given by BECCARI and from the Singapore duplicates of the specimens cited by BECCARI, the flowers of the specimens cited under *L. Ridleyana* and *L. acutifida* var. *peninsularis* (see *L. confusa*) appear to have been interchanged either by RIDLEY at the

time of distributing his collections or by BECCARI at the time of drafting his description. In the Singapore herbarium spadices of RIDLEY 9806 (cited by BECCARI under *L. acutifida* var. *peninsularis*) and RIDLEY 14112 (Haptoholotype of *L. Ridleyana*) still bear flowers; but RIDLEY 9806 has flowers depicted for *L. Ridleyana* and RIDLEY 14112 has flowers depicted for *L. acutifida* var. *peninsularis*. As I have typified the species on the characters of flowers, which are more stable and of better diagnostic value than the characters of leaves, spathes, etc., investigators should note these points in case discrepancies be noticed in the original specimens of these two taxonomic units.

As described by BECCARI, *L. Ridleyana* approaches very near to *L. malajana* which has however branched partial inflorescences. (see also observations under *L. confusa*).

22. **Licuala Scortechinii** Becc., Malesia III (1889) 192; Hook. f., Fl. Brit. Ind. VI (1892) 434; Ridl., Mat. II (1907) 164; Becc. in Webbia V (1921) 37 et 49; Ridl., Flora V (1925) 30; Becc. in Calc. Annals XIII (1933) 208 tt. 13–IV, 59 et 59 bis.

MALAY PENINSULA: *Kedah,* Gunong Jerai =Kedah Peak (Haniff in May 1904; Ridley, 5201; Robinson and Kloss, 6016).

This species was based on a specimen collected by SCORTECHINI in Perak where it has not been found again.

23. **Licuala spinosa** Wurmb in Verh. Bat. Genootsch. II (1780) 469; Bl., Rumphia II (1844 ?) 39 tt 82 et 88; Hook. f., Fl. Brit. Ind. VI (1892) 431; Ridl., Mat. II (1907) 160; Becc. in Webbia V (1921) 34 et 47; Ridl., Flora V (1925) 25; Becc. in Calc. Annals XIII (1933) 186 t. 84.

MALAY PENINSULA: *Perlis,* Mata Ayer (Henderson, 23061). *Kelantan,* Sungai Keteh (Nur, 12077). *Lankawi,* common (Curtis, 2129); Coah (Curtis, 3419). *Pahang,* Pekan (Ridley on Aug. 20, 1889); Tasek Bera (Henderson, 24433); Pulau Tioman (Nur, 18901; Burkill in June 1915). *Perak,* Dindings (Ridley, 3170); Matang Jambu (Wray, 2527). *Malacca,* Bukit Bruang (Hassan, 25). *Johore,* Sungai Segal in Muar (Fox, 11303); Sungai Rhu (Corner, 28485); Sungai Sedili in Mawai (Holttum & Corner, on 16 May 1932); Pulau Tinggi (Feilding in 1892). *Singapore,* Pulau Ubin (Ridley, 5121 et 3166; Hullett on 9 Nov. 1884); Pulau Battam (Ridley in 1890 and in 1891); Pulau Brani (Ridley in 1900); Changi (Ridley in April 1889).

Distribution: Lower Burma, Siam, Indo-China, Andamans, Sumatra, Java, Borneo, and the Philippines.

24. **Licuala tiomanensis** Furtado **sp. nov.** Fig. 9.

Inter species inflorescentias partiales simplices gerentes calyce majore superficialiter lobato dense adpresse piloso sat distincta. Facie florum L. modestæ *similis, sed spadicibus longioribus, inflorescentiis partialibus remotioribus simplicibus dissimilis.*

Palma humilis. *Petiolus* unicus tantum visus, 22 cm. longus, infra medium aculeatus. *Segmenta* foliorum multa, inaequalia, cuneata; medianum maximum, circa 28 cm. longum, 9 cm. latum, pluricostatum; basilaria 2–costata, minima, 15–17 cm. longa, circa 2 cm. lata; intermedia 3–4 costata. *Spadix* circa 80 cm. longus, in ramos 2–3, pilosos, simplices, infra spathæ apicem orientes divisus. *Spathæ* tubulosæ, fugaceo-furfuraceæ. *Flores* immaturi lanceolati, 6–8 mm. longi, super pulvinos prominulos plerumque geminati. *Calyx* 4 mm. longus, dense pilosus, apice truncatus, breviter lobatus vel in 3 lobos obscure fissus. *Corolla* ante anthesin calyce 1/3 longior, puberula, lobis acutis. *Annulus* staminalis conspicuus, in 6 filamenta abrupte subulata divisus. *Ovarium* glabrum.

MALAY PENINSULA: *Pahang,* Bukit Kajang in insula Tioman, alt. 3,300 ped. (Nur, 18611).

This species resembles *L. Ridleyana, L. peninsularis,* etc. in having simple branches to the spadix, but in the characters of the flowers it is easily confused with *L. modesta.* Unfortunately *L. tiomanensis* is known only from a single specimen containing only one leaf which may not be typical of the species. Fruits are not known.

NUR, 18910 collected also on Gunong Kajang in Pulau Tioman at an alt. 2,500 ft. seems to belong here, but no flowers are present in the Singapore herbarium, though from the collector's notes it appears that the flowers were present in the collection. The petiole is very much longer in this specimen and may have been over 3½ feet long; the partial inflorescences arise very high above the apex of the spathes. The collector notes that the plant which supplied this specimen is 15–20 feet in height.

25. **Licuala triphylla** Griff. in Calc. Journ. Nat. Hist. V (1845) 332 et Palms Brit. Ind. (1850) 126 t 225; Hook. f., Fl. Brit. Ind. VI (1892) 432; Ridl., Mat. II (1907) 163; Becc. in Webbia V (1921) 33 et 46; Ridl., Flora V (1925) 28 t. 211; Becc. in Calc. Annals XIII (1933) 182 tt. 9–V et 96.

L. pygmaea Merr. in Univ. Calif. Publ. Bot. XV (1929) 20. **Syn. nov.**

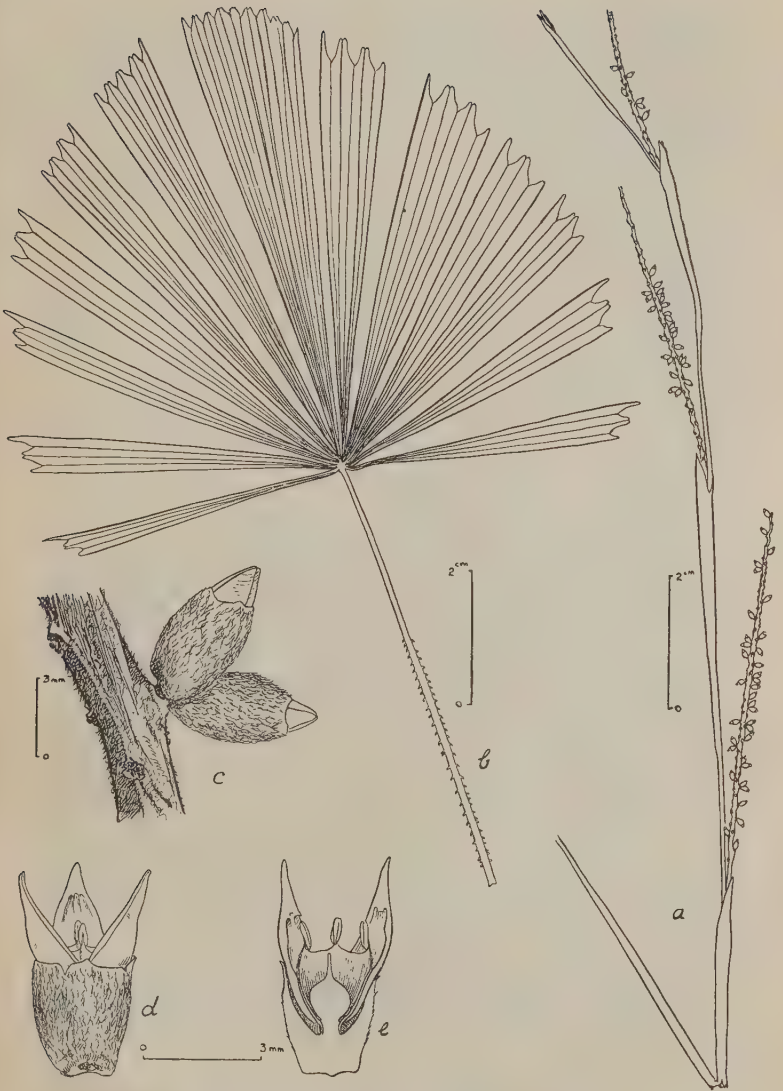


Fig. 9. Licuala tiomanensis (Holotypus: NUR 18611).

a. Pars spadicis. **b.** Frondis lamina cum parte petioli. **c.** Pars spicae cum alabastris. **d.** Flos ad anthesin. **e.** Flos verticaliter discissus ut filamenta staminum et ovarium appareant.

L. triphylla var. *integrifolia* Ridl., Mat. II (1907) 164; Becc. in Webbia V (1921) 33 et 46; Ridl., Flora V (1925) 28; Becc. in Calc. Annals XIII (1933) 184. **Syn. nov.**

MALAY PENINSULA: *Kedah,* Bukit Seblak at Weng (Furtado, 33069). *Pahang,* Gunong Senyum (Henderson, 22356); Batu Talam near Raub (Burkill & Haniff, 16959); Lubo Pellang (Ridley in 1891, the holotype of the var. *integrifolia*); Pulau Tijou (Ridley in 1891); Dong near Raub (Burkill & Haniff, 16911). *Perak,* Kroh (Furtado, 33041); Bujong Malacca (Curtis in Aug. 1898); Gunong Tungul in Dindings (Ridley in May, 1896 and July 1898). *Negri Sembilan,* Tampin (Burkill, 3212; Nur 1308). *Malacca,* Chabau (Alvins, 2306 as Palas Revang); Ayer Panas (Ridley & Goodenough, 1628); Malacca Town (Alvins, 655, as Gurcheng or Palas Tikus); Bukit Bruang (Curtis, in May 1901). *Johore,* Sungai Tebrau (Ridley, 13234); Bukit Keara in Muar (Fox, 11301; Ridley in 1902); Sungai Buloh Kasap (Corner on 5 Jan. 1936); Bukit Tinjau Laut (Corner, 37079). *Singapore,* Changi (Ridley in 1891 & 1894).

BRITISH NORTH BORNEO: Tawao (Elmer, 21635, Haptosyntype of *L. pygmaea*).

Distribution: Bangka (?) *fide Beccari.*

L. triphylla is a very variable species as regards the number of the leaf segments and the size of the petiolule of the median segment, some median segments being quite sessile. Owing to these variations field studies are necessary to see whether *L. pusilla* is a special form of this species. *L. triphylla* flowers when the plants are very small, so that leaves showing no divisions or leaves partially divided into 2 or 3 lobes may be found. In the holotype of *L. triphylla* var. *integrifolia* some leaves have very narrow segments at the base; these have been ignored by RIDLEY in describing the variety. Transitions from this to many-segmented leaves are many.

Many leaves bear sessile median segments, so that this cannot be taken as an invariable character of the species. GRIFFITH'S plate depicts leaves with sessile median lobes and so also RIDLEY'S figure which appears to have been based mainly on GRIFFITH'S plate.

I cannot separate *L. pygmaea* from *L. triphylla* on any characters. The median segment in the duplicate specimen in Singapore shows a distinct tendency to petiolulation.

6. Summary and Conclusions

This paper contains the results of a study of the *Licuala* species indigenous in the Malay Peninsula.

Though Licualas present little difficulty for collecting herbarium specimens, yet they are not well represented in the herbarium. The principal reason for this is that some experience is required before the collector is able to distinguish between the different species he meets with in the field, and so very often rare species, being mistaken for the common ones, are omitted in the collection. Hence some hints are given in this paper to enable the collector to distinguish readily between the species of a given area.

An inquiry into the affinities of the Malayan species revealed the necessity of revising the subdivisions of the genus. The previous subdivisions were mostly based on the branching of the spadices, a character very variable and therefore unsatisfactory for the purpose. It has been found also that all *Licuala* species produce a dorsal embryo in the fruit so that the definition that PERICYCLA includes species with basal embryo is untenable. The only stable character which can be employed to place allied species into large groups is found in the androœcium, and in the nature of its divisions.

As revised here, the genus *Licuala* consists of three subgenera: LIBERICULA (new), EU-LICUALA and PERICYCLA, the second subgenus being again subdivided into four sections: WURMBIA (new), BONIA (new), BECCARIA (new) and DAMMERA (new state). The subgenus LIBERICULA and the sections BONIA and BECCARIA are monospecific, containing respectively: *L. peltata* (in monsoon forests in North-East India, Assam, Burma, Andamans and Thailand (Siam)), *L. fatua* (Indo-China) and *L. reptans* (Borneo). Of the section DAMMERA only two species are known, both from New Guinea. The subgenus PERICYCLA has been re-defined to include all the species which are allied to *L. penduliflora* (Bl.) Miq., the type of the subgenus; these inhabit the tropical and sub-tropical regions in Oceania, one occurring in Australia, a few in the small islands west of the Solomon Islands, and the rest in New Guinea. The section WURMBIA includes the great majority of the *Licuala* species, the greatest number of these being limited to the Malay Peninsula, Sumatra and Borneo, though some also occur outside this region in Burma, Indo-China, South China, Java, Philippines, Celebes and New Guinea. Usually the distribution of the individual species of this section is very limited; *L. spinosa*, the type of the section, is the most widespread, being also of a frequent occurrence throughout the Malay Peninsula.

There are in all twenty-five species indigenous in the Malay Peninsula. Of these *L. peltata* is the only species that is not a member of WURMBIA. Besides *L. peltata* and

L. spinosa, four peninsular species are known or reported to occur wild outside the Malay Peninsula, namely *L. ferruginea, L. longipes, L. paludosa* and *L. triphylla;* they are also fairly widespread within the Peninsula itself. The other nineteen are all endemic, most of them being apparently restricted to small regions in the Peninsula. Much of this endemism may be more apparent than real, because, owing to the difficulty of distinguishing Licualas in the field, the species are not well represented in the collections. Furthermore, recent collections from Sumatra, Borneo, and Siam have not yet been worked out.

The new name **L. Beccariana** has been proposed for the New Guinea species, previously known as *L. racemosa* Becc. (DAMMERA), non *L. racemosa* Bl. (WURMBIA). In addition nine new species have been described from the Malay Peninsula: **L. confusa, L. Corneri, L. kemamanensis, L. Kiahii, L. longicalycata, L. mirabilis, L. Moyseyi, L. pahangensis,** and **L. tiomanensis.**

The following names have been reduced in the synonymy: *L. acutifida* var. *peninsularis* (L. confusa, doubtful), *L. longepedunculata* (L. glabra), *L. paniculata* and *L. patens* (L. paludosa), *L. pygmaea* (L. triphylla), *L. racemosa* Becc., non Bl. (L. Beccariana), *L. triphylla* var. *integrifolia* (L. triphylla) and *L. Wrayi* (L. modesta).

It has been shown that *L. ferruginoides* produces at times branched partial inflorescences (vide observ. sub. *L. ferruginea*) and that a further inquiry is needed before Beccari's reduction of *L. amplifrons* to *L. paludosa* can be accepted as final.

7. Index to the Collector's Numbers

Alvins: 655 & 2306(25). **Anderson:** 164(16); 171 & 177(16). **Best:** 7711(11); 13884(5). **Boden-Kloss:** 14614(19). **Burkill:** 1171 & 1417(13); 3212(25); 9021(15). **Burkill & Haniff:** 12551 & 12589(16); 12873 & 12948(16); 16911 & 16959(25); 17460(10). **Burkill & Holttum:** 7842(5); 8426(6). **Corner:** 28485(23); 28688(4); 30072(3); 30072A(14); 30111 (13); 30398(4); 30520(7); 30547(14); 30739(11); 37068(11); 37079(25). **Curtis:** 1010(1); 2077(16); 2129(23); 3162(9); 3419(23). **Derry:** 633(5). **Elmer:** 21635(25). **Fox:** 163(16); 3529(16); 11301(25); 11303(23). **Furtado:** 33037 & 33054(15); 33069(25); 33125(13); 37103(16). **Goodenough:** 1360(20); 1406 (13); 1962(13). **Haniff & Nur:** 4720(A); 6962(9); 8111(5); 10104(14). **Hassan:** 25(23). **Henderson:** 10559(13); 10623(18); 19434(14); 19686(20); 22305 (18). 22356(25); 23061(23); 23804(16); 24433(23);

29725(5); 33041(25). **Holttum:** 9252(12); 9260(4); 9557(13); 10601(16); 10605(4); 10792(11); 24560 (13); 24944(4). **Hullett:** 852(5). **Hume:** 7619(20); 7962(2); 9437(10). **Kiah:** 24256(5); 32137(8); 32401 (12). **Kiah & Moysey:** 31840(17); 33398(14); 33399(6). **Kloss:** see **Boden-Kloss.** **Lobb:** 280(1). **Moysey:** see **Kiah & Moysey.** **Nur:** 1308(25); 11571 (13); 12077(23); 18611(24); 18901(23); 18910(24 obs.); 19968(14); 25167(4); 34076(19). **Ridley:** 3166 (23); 3167(16); 3168(4); 3170(23); 3473(5); 3474 (13); 3512(4); 5121(23); 5201(22); 6676(4); 7894(5); 9804(9); 9805(21); 9806(21) 10120(13); 10121(13); 10239(2 obs.); 10329(2 obs.); 10793(13); 11212(19); 11406(16); 12117(6); 12198(11); 13234(25); 13519 (4); 14112(2); 14709(10); 14721(16); 15881(6). **Ridley & Goodenough:** 1577(13); 1628(25). **Robinson & Kloss:** 6016(22). **Spare:** 33288(19). **Symington:** 24379(12); 24380(4); 25612(9); 25724(9); 47068(12); 47092(12).

8. Index to the Botanical Names

Sectional and Subgeneric names in small CAPITALS. New names in **bold faced** type. Synonyms in *italics*.

BECCARIA
BONIA
DAMMERA tr. nov.
DAMMERA subg.
EU-LICUALA
LIBERICULA
LICUACELLA
Licuala:
acutifida
acutifida var. *peninsularis* (obs.)
amplifrons (obs.)
Beccariana nom. nov. (gen.)
confusa sp. nov.
Corneri sp. nov.
ferruginea
ferruginoides (obs.)
glabra
glabra var. selangorensis
grandis (gen.)
kemamanensis sp. nov.
Kiahii sp.n.
Kingiana
Kunstleri
lanuginosa
longepedunculata
longicalycata sp.n.
malajana
Licuala:
mirabilis sp.n.
modesta
Moyseyi sp.n.
pahangensis sp.n.
paludosa
paniculata
patens
peltata
pusilla
pygmaea
racemosa (gen.)
Ridleyana (obs.)
Rumphii (gen.)
Scortechinii
spinosa
tiomanensis sp.n.
triphylla
triphylla var. *integrifolia*
Wrayi
LICUALINA
LICUALOPSIS
Pericycla emend. (obs.)
PERICYCLA
WURMBIA

THE FERN GENUS DIPLAZIUM IN THE MALAY PENINSULA

by R. E. Holttum

General

The ferns of the genus Diplazium occurring in the Malay Peninsula are all, with the exception of *D. esculentum* and *D. polypodioides,* found on the ground in shady forest, many of them only in moist places near streams. They are especially characteristic of the valleys at medium elevations in the mountains, though a few species are common in the more open parts of the forest. There are no epiphytes and no climbing species among them. Nearly all have short erect rootstocks (sometimes developing a short trunk) and tufted fronds, sterile and fertile fronds being almost alike.

There is comparatively little difference of external form among the species of the same degree of division (*i.e.*, among pinnate and among bipinnate species), and there is of course a certain amount of variation according to age and influences of habitat, so that the clear distinction of species is at first sight difficult, and there has in fact been much confusion in the past. I have found, however, that the characters of the scales are most useful in distinguishing species of similar habit, and I believe that I have arrived at a clear distinction of our local species, with the possible exception of *D. Prescottianum.*

I have been unable to identify four of our species with any described from places outside the Peninsula, and so have described them as new. There are undoubtedly a very large number of species within the Malayan region, but I think that a good many have been described more than once. The descriptions are, however, inadequate as a basis for comparison, and much herbarium material is incomplete (part only of a leaf, or lacking in scales, or representing an immature stage). A study of much material over a wide area is necessary before a proper account of the genus in the Malayan region can be given.

Diplazium cordifolium provides a remarkable case of polymorphism leading to confusion of names. Young plants develop rather large simple fronds which are often fertile, and this stage may persist indefinitely, especially in the lowlands. Mature plants, however, often bear pinnate fronds with several pairs of pinnæ. The two stages have been separately named; and the fact that other superficially similar simply pinnate species have sometimes a few veins anastomosing has also led to confusion between these and the mature form of *D. cordifolium.* The young

stages of species may be characteristic, and so useful diagnostically, in this genus as in other fern genera, but they have been little studied. I have noted especially the early stages of *D. bantamense* and *D. riparium.*

In the following account of the species found in the Malay Peninsula, I have not attempted to give full lists of synonyms. There has been so much confusion in the application of names that such lists of synonyms would be difficult to compile accurately. I believe that the names used are all correctly applicable to our species; but I differ in some cases from the usage of the recent book by Backer and Posthumus on the ferns of Java. In such cases, the synonymy is briefly discussed.

As regards citation of specimens, this is done only where I believe there has been confusion in the past, or in the case of new species; in cases of well characterized species such as *D. accedens* and *D. cordifolium* there seems no need for the publication of lists of specimens. Specimens collected in our Singapore Field Number series (started by Burkill in 1912) are cited as S.F.N. Duplicates of many of these will be found in other herbaria, in some cases under other names than those now given. A list of numbers at the end of this paper may therefore prove helpful. It should be noted that the earlier distribution labels did not bear the words "Singapore Field Number".

A fairly full description is given for each species. To aid in the identification of specimens, the most distinctive characters in each description are italicised.

Distribution

Until a full investigation is made, it is impossible to give a complete picture of the distribution of the species of Diplazium found in the Malay Peninsula. There are certainly cases in which one name is used in different countries to cover different species, and conversely the same species sometimes goes by different names in different countries. From the material at my disposal in the Singapore herbarium, it is, however, possible to make a few generalizations.

A few Malayan species certainly have a wide distribution, notably the two that grow in open places, *D. polypodioides* and *D. esculentum.* These both appear to extend from N. India and S. China right through the Malayan region to N. Guinea or beyond. *D. polypodioides* has various synonyms, and it appears that specimens from India and China need checking against the Java type.

D. accedens may have an even wider distribution if it should be found indistinguishable from *D. proliferum,* of which the type comes from the Mascarene Islands. A

similar case is that of *D. silvaticum* (type from Mauritius), but this is a less well characterized species, and its true Asiatic distribution is in doubt.

D. sorzogonense is another interesting case of a widely distributed species. This has undoubtedly been confused with *D. speciosum* and probably also with other species, but I have seen quite typical specimens from the Philippines and New Guinea. It is perhaps significant that this species is found in lowlands and mountains alike in Malaya, and is not confined to the most moist and shady places. *D. speciosum,* on the other hand, is certainly more restricted in distribution, and in Malaya is only found in the mountains, the typical form only (hitherto) on G. Tahan on the east side of the Peninsula.

D. montanum is a case of more restricted distribution. Our ferns which I now so name were formerly called *D. pallidum.* The latter species, however, as found on the mountains of Java and Sumatra, is clearly distinct, and I find that our ferns agree with the type of *D. montanum* from Sumatra. *D. montanum* appears to occur at lower altitudes in east and south Sumatra; *i.e.,* those parts adjacent to Malaya.

D. heterophlebium is our only case in this genus of a species finding the southern limit of its distribution in Malaya.

So far as our present knowledge goes, the following species appear to be confined to the Malay Peninsula: *D. insigne, D. subintegrum, D. velutinum, D. procumbens, D. Kunstleri, D. simplicivenium.* All these are ferns of the moist, shady mountain valleys.

D. insigne is a remarkable fern of the alliance of *D. accedens* but very large. *D. subintegrum* is allied to *D. pallidum* but in my opinion quite distinct. *D. velutinum* is probably the most local of all, a derivative of *D. tomentosum. D. procumbens, D. Kunstleri* and *D. simplicivenium* are distinct members of the very large bipinnate group, the Peninsular species of which have been mostly hitherto lumped under the names *D. dilatatum* or *D. latifolium.*

Characters of the Genus

There has been much discussion on the status of the genus *Diplazium* and on its relationship to *Athyrium.* I do not feel that I can offer any new evidence, more especially as the typical species of Athyrium (in the stricter sense) occur outside Malaya. In view of Christensen's remarks in this Bulletin, Vol. 7, p. 268, and in view of the fact that in Malaya Diplazium and Athyrium are quite distinct, I here maintain the genus Diplazium, as in Christensen's *Index Filicum.*

The principal characters of the genus may be summarized as follows:—

Stock usually short, erect, sometimes forming a short trunk, in a few cases creeping, but (in Malayan species) the fronds always tufted; roots rather coarse, black, sometimes forming a very close mat on the surface of the ground. Scales on young fronds orbicular to linear, edges entire or toothed, the cells usually elongated, walls of rather uniform thickness, colour throughout medium to dark brown (never clathrate), the teeth where present always formed of two adjacent cells, the ends of which may separate; edges of scales also provided sometimes with short glandular hairs. Stipes relatively stout, sometimes bearing papillae or spines near the base or throughout, these prominences being the bases of fallen scales. Rachises glabrescent, minutely scaly or in a few species hairy on the rounded lower side, papillate in the grooved upper side. Midribs of pinnae and pinnules grooved above, the edges of the groove often strongly winged, the wing often interrupted and/or extended at the junction of the midrib of a pinnule or the main vein of a lobe. Lamina simple, pinnate or bipinnate, texture mostly thin, pinnae and pinnules of bipinnate fronds with subequal base, the venation never anadromous. Veins in most species free, in a few species adjacent vein-groups anastomosing more or less freely. Sori elongated along the veins, with lateral indusium; the lowest acroscopic sorus in any group usually double (diplazioid), and occasionally other sori double also; double sori usually with two quite separate indusia, never grading into a horse-shoe shape with indusium continuous all round.

As compared with the above description, most species of Athyrium have an anadromous venation and division,

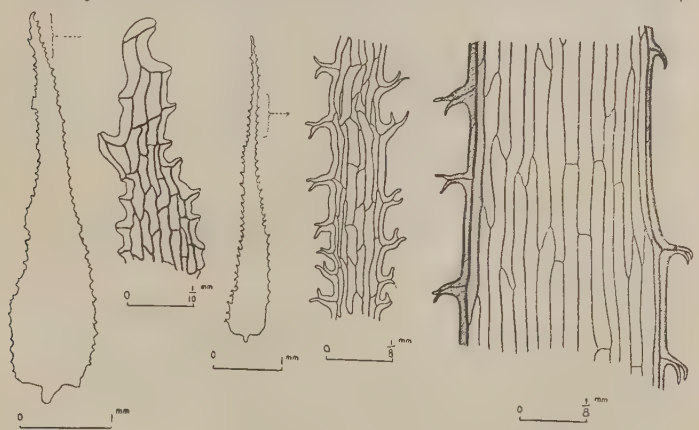


Fig. 1. Scales from base of stipe. On left, *D. crenatoserratum*, outline of single scale and apex enlarged. Centre, *D. silvaticum*, same, showing forked teeth. On *right, D. accedens*, middle part of scale; shaded cells at edges are black.

the pinnules often with very unequal bases, the scales are always relatively broad and entire, usually rather pale and thin, and the sori are always short and broad, the diplazioid ones often of a horse-shoe shape, the two sides of the sorus being connected.

In the character of grooved upper surface of costæ and costules and the winged margins of the groove, both Diplazium and Athyrium agree with Eu-Dryopteris and Polystichum rather than with Thelypteris; and the teeth on the scales on certain species of Diplazium are similar in structure to the teeth of Dryopteris and Polystichum. No scales in Athyrium or Diplazium (so far as I have observed) have hairs on the margin as found in many species of Thelypteris and Cyclosorus.

The markedly anadromous leaf-architecture found in many species of Athyrium is matched in the group of species formerly called Polystichum but now separated by Ching as Rumohra. Such leaf-architecture does not occur in Thelypteris.

It appears therefore that Athyrium and Diplazium are more nearly related to Eu-Dryopteris than to Thelypteris.

Though the leaf-architecture in many species of Athyrium is anadromous, there are clearly catadromous species (*e.g. A. silvaticum*) commonly referred to that genus. It seems possible that the type of leaf-architecture may afford a useful character in subdividing the genus.

The true Athyriums in the Malayan region are all species of rather high mountains (which is probably the reason why they are little represented in Malaya, which has much less high land than the great Sunda Islands), whereas species of Diplazium, as noted above, are characteristic of lowlands and medium elevations in the mountains.

Key to the Species of Diplazium of Malaya

N.B.—This Key applies only to full-grown plants.

Fronds simple.
- Fronds to 4 cm. wide, narrow at base .. .. .. *D. subserratum*
- Fronds more than 4 cm. wide, broadly cordate at base .. *D. cordifolium*

Fronds simply pinnate.
- Scales entire, not toothed
  - Veins anastomosing copiously
    - veins anastomosing near costa *D. heterophlebium*
    - veins anastomosing only in marginal third of lamina .. *D. cordifolium*

Veins free or only slightly anastomosing
fronds to about 15 cm. wide, costæ hairy beneath .. *D. tomentosum*
fronds usually wider, costæ not hairy beneath
pinnæ cut half way or more to costa
sori impressed, rachis fibrillose, veinlets to 10 pairs .. *D. sorzogonense*
sori not impressed, rachis not fibrillose, veinlets to 7 pairs *D. malaccense*
pinnæ cut less than half way to costa
pinnæ to 5 cm. or more wide
veins at 45° to costa, pinnæ to 12 pairs .. *D. xiphophyllum*
veins at more than 60° to costa, pinnæ to 5 pairs .. *D. riparium*
pinnæ under 5 cm. wide
lower veinlet of group simple or once forked .. *D. montanum*
lower veinlet more copiously branched
2 veins of each group soriferous .. *D. subintegrum*
4–6 veins of each group soriferous *D. Prescottianum*
Scales toothed
Veins much anastomosing .. *D. accedens*
Veins free or only occasionally joining near margin
pinnæ subentire, more than 2 cm. wide .. *D. bantamense*
pinnæ lobed, or if entire, less than 2 cm. wide
pinnæ lobed ¾ or more towards costa .. *D. speciosum*

pinnæ lobed less than ¾ towards costa
pinnæ thin in texture, not auriculate below, scales strongly toothed — *D. silvaticum*
pinnæ thicker in texture, often auriculate below, scales irregularly and shortly toothed .. — *D. crenatoserratum*

Fronds bipinnate.
Veins anastomosing
stipes smooth, pinnules usually less than 2 cm. wide, lobed about ¼ to costa .. .. — *D. esculentum*
stipes spiny, pinnules always more than 2 cm. wide, toothed only .. .. .. — *D. insigne*
Veins free
scales ± round, peltate, entire
sori very short, basal on veins — *D. latisquamatum*
sori longer, medial on veins .. — *D. Kunstleri*
scales much longer than broad
frond to about 30 cm. long .. — *D. velutinum*
frond much longer
lobes of pinnules 3–4 mm. wide, cut more than ¾ to midrib — *D. polypodioides*
lobes of pinnules 7 mm. or more wide, cut less than ¾ to midrib
rhizome procumbent, fronds to 80 cm. long — *D. procumbens*
rhizome erect, fronds to more than 100 cm. long
lower pinnules sessile, to c. 2 cm. wide, veins to 5 pairs, all simple — *D. simplicivenium*
lower pinnules on stalks to 5 mm. long, to more than 2 cm. wide, veins 5–8 pairs, some forking .. — *D. dilatatum*

1. Diplazium accedens Bl. Enum. 192. 1828.

Stock stout erect, sometimes a short trunk. *Stipes stout, green, covered with soft green protuberances near base,* to c. 60 cm. long; when young covered with narrow scales, each on the end of a protuberance, the scales to 1·5 mm. wide at base, dull brown, thick in texture, with narrow black toothed edge (*see* fig. 1). *Lamina simply pinnate,* to 120 cm. or more long and 50 cm. wide, pinnæ about 15–jugate; apex of frond like the lateral pinnæ or with 1 or 2 deep lobes at the base; rachises and costæ glabrescent, smooth, *buds common in the axils of the pinnæ.* Lower pinnæ on stalks to 8 mm. long, upper sessile, gradually smaller. *Largest pinnæ to 40 × 8 cm.,* base truncate or very broadly cuneate, sides parallel for 2/3 or more of the length of the pinnæ, then tapering to acute apex, *edges entire or very shallowly lobed,* the lobes slightly toothed. Main lateral veins in the pinnæ about 8–12 mm. apart on the costa, at about 60° to the costa, each bearing up to 10 pairs of lateral veinlets, the *lateral veinlets of adjacent groups anastomosing when they meet and so producing a series of parallelogram-shaped areolæ;* anastomosis of small veins near edge of lamina irregular. Sori on some or all the veinlets, often throughout their length.

A fern of shady mountain stream-sides found in Malaya only on the Main Range and Taiping Hills. Sometimes in very large fronds there are extra areoles between the normal groups adjacent to the main lateral veins; a specimen having this character formed the basis of *Athyrium Ridleyi* Copeland, which I include in the present species.

This species is closely related to *D. proliferum* (Lam.) Thouars, and the two should perhaps be united; if so, the species in this broader sense would extend from the Mascarene Islands to the Pacific. A study based on material from all parts of this wide range is required to decide on the status of *D. accedens* and *D. proliferum.*

As regards the name *D. accedens,* the situation is a little complicated. It appears that the three names *D. accedens, D. repandum* and *D. Swartzii,* all published in the same book by Blume, are to be regarded as synonymous. Later authors have in many cases regarded all as synonyms of Lamarck's earlier name, or of *Asplenium decussatum* Sw.; the names *Swartzii* and *accedens* have been taken up and used in the genera Callipteris, Asplenium and Athyrium, but the name *D. repandum* appears to have been almost or entirely ignored. Backer and Posthumus (1939), however, have revived the name *D. repandum,* apparently on grounds of page priority (though they do not state this) which is not admitted by the Rules. In their synonymy, however,

they include *Diplazium proliferum* Thouars, an older name; their use of the name *D. repandum* is therefore contrary to the rules.

It appears to me that, if the Malaysian fern is to be regarded as specifically distinct from that of the Mascarene Islands, the name *Diplazium accedens* Bl. is the appropriate one to use, as this name has already been used by Christensen in the 3rd Supplement to his *Index Filicum* (1934), and had previously been used in a varietal sense for Java ferns by van Alderwerelt van Rosenburgh.

2. Diplazium bantamense Bl. Enum. 191. 1828.

Stock short suberect. Stipes to 60 cm. long, glabrescent, clothed at the base with *brown scales about 1 cm. long and 1·5 mm. wide at base, edges finely toothed. Frond simply pinnate,* to about 60 cm. long and 25 cm. wide, *pinnæ up to about 8 pairs,* terminal pinnæ similar to the others or occasionally with a large lobe at the base; *a bud often present on the rachis at the base of one of the upper pinnæ.* Basal pinnæ on stalks 3 mm. long, base slightly unequal, on the lower side rounded and on the upper side cuneate at 45° and decurrent; bases of the upper pinnæ more equally rounded. *Sub-basal pinnæ largest,* up to about 20 by 7 cm., *commonly about 12 by 4·5 cm.,* widest a little above the base, then narrowed gradually to the acuminate apex; *edges entire or toothed only near the apex,* texture firm; veins usually distinct on both surfaces but sometimes obscure, at rather more than 45° to the costa, forked at or near the costa, the upper branch simple and often soriferous almost throughout its length (diplazioid sorus), the lower branch forked again 1–3 times, 1–3 of the branches often bearing short simple sori towards the margin; occasionally a slight anastomosis of veins towards the margin; indusia narrow, persistent.

Young plants have fronds with simple lamina to about 15 by 5 cm., deeply cordate or almost sagittate at the base, later fronds having one or more pairs of lateral pinnæ below the terminal lamina. This behaviour is closely similar to that of *D. cordifolium;* but *D. cordifolium* develops a much larger simple lamina, which usually becomes fertile, before producing fronds with free lateral pinnæ.

The name *D. bantamense* has in the past been given to all Peninsular specimens of Diplazium with free veins and rather broad subentire pinnæ. These I now separate into *D. bantamense* with toothed scales, *D. xiphophyllum* and *D. riparium* with entire scales. I find that *D. bantamense* as above described agrees well with Java specimens, and hence, though I have not seen the type, I feel confident that I have selected the correct Peninsula

fern to bear this name. It is a fern of moist shady forest, chiefly in the hills, sometimes near streams in lowland forest. In the shape of its pinnæ, it most nearly resembles the pinnate form of *D. cordifolium*, but the much anastomosing veins of the latter distinguish it.

Specimens in Singapore Herbarium:—

TRENGGANU. Kuala Berang, on streambank, Holttum s.n., 14.5.1925.

PAHANG. Fraser's Hill, 4,000 ft., S.F.N. 10018 (Holttum & Burkill); S.F.N. 11473 (Holttum); S.F.N. 36505 (Holttum). Cameron Highlands, Robinson Falls, 4500 ft., S.F.N. 17978 (Henderson); 4,800 ft., S.F.N., 23340 (Holttum). Sungei Teku, 500 ft., S.F.N. 20554 (Holttum).

PERAK. Waterloo, Curtis 1361 p.p. (narrow toothed pinnæ, and apical pinna lobed; a doubtful specimen). Ulu Temango, Ridley 14229. Taiping, 300–500 ft., King's Collector 8388. Upper Perak, 300 ft., Wray 3616.

NEGRI SEMBILAN. Ulu Bendul, S.F.N. 9876 (Holttum).

SELANGOR, near the Gap, 2,700 ft., S.F.N. 37159 (Addison).

PENANG, near Tiger Hill, 2,500 ft., S.F.N. 19346 (Holttum).

3. **D. cordifolium** Bl. Enum. 190. 1828.

Stock short erect. Stipes to 50 cm. or more long, clothed at the base with brown scales about 1·0 cm. long and 1·5 mm. wide at base, *edges of scales entire. Fronds of two kinds, either simple with cordate base, or pinnate with ovate entire pinnæ;* transition forms also occur, but fully-grown plants may bear simple fronds. *Lamina of simple fronds to 35 cm. long and 12 cm. wide, the base cordate* (often with a bud on the costa close to the base) the apex more or less acuminate, the margin entire; texture thin but firm, veins clearly visible on both surfaces; veins at more than 60° to the midrib, forked close to the midrib, the lower branch forked again, lateral members of the groups so formed anastomosing about half-way towards the margin, *the outer part of the lamina containing a series of narrow areoles about 1 mm. wide and 1 cm. or more long.* Sori on the outer veins of each group and also on some of the inner veins, anastomosing with the veins, and reaching almost to the edge of the lamina; indusia narrow, persistent. *Pinnate fronds with 1–8 pairs of pinnæ* below the terminal lamina, which is smaller as the number of lateral pinnæ increases. Lateral pinnæ sessile or the lowest very shortly stalked, varying much in size, the basal pinnæ largest, upper ones

gradually smaller; base of pinnæ subequally rounded, *margins quite entire,* apex shortly acuminate; largest pinnæ usually 12–16 cm. long and from 2·5 to 6·5 cm. wide; *veins as in the simple lamina above-described,* but more oblique to the midrib of the pinnæ (at about 45°).

This species is frequent in both lowland and mountain forest in Malaya but is never found in the open. In the lowlands it rarely (if ever) develops beyond the stage of simple fronds, and in the mountains it appears that some plants remain for a considerable time at this stage, which is usually fully fertile. It is common, however, in mountain forest to find plants which have one or more pairs of lateral pinnæ below the cordate terminal lamina, and all stages of transition can be found up to fronds with 7 or 8 pairs of lateral pinnæ. Specimens of the latter have usually been named *D. fraxinifolium* Pr. or *D. lineolatum* Bl., simple fronds being called *D. cordifolium.*

Backer and Posthumus (*Varenflora voor Java,* p. 123), recognizing that both simple and pinnate forms belong to one species, use the name *D. fraxinifolium* Presl. Presl's name was published prior to *D. cordifolium,* but the description is very inadequate (anastomosis of veins is not even mentioned) and I think it better to use Blume's name, which is well established. Owing to the polymorphism of this species, and to the superficial resemblance of pinnate forms to *D. bantamense* Bl., there has been much confusion of names.

The parallel between *D. bantamense* and *D. cordifolium* is a close one. Both ferns have at first simple fronds, and later one or more pairs of lateral pinnæ which are broad and sub-entire. There are, however, several clear differences. The scales are toothed in *D. bantamense* and entire in *D. cordifolium;* the veins are almost always quite free in *D. bantamense* but copiously anastomosing in *D. cordifolium;* and the initial stage of simple lamina is much more developed in *D. cordifolium,* being often fertile, whereas the simple lamina of *D. bantamense* is only found in young plants and is rarely fertile.

I think it unnecessary to cite the many specimens of this species which have been obtained in all parts of Malaya.

4. **D. crenatoserratum** (Bl.) Moore, Index 121. 1859. Asplenium Bl. Enum. 177. 1828.

Stock short, erect. *Scales* on young fronds and bases of stipes *to about 4 by 1·5 mm., acuminate, edges irregularly and shortly toothed, teeth not forked* (*see* fig. 1). Stipes to about 30 cm. long. Fronds simply pinnate, commonly about 30 cm. by 15 cm., sometimes larger, pinnæ numerous, close, the upper adnate, grading into the lobed deltoid apical

lamina, the lower longest, on stalks to 5 mm. long, commonly about 15 by 2 cm., sometimes larger, texture firm. *Pinnæ of fronds on young plants with bluntly rounded apex,* edges almost entire, base truncate and slightly auricled above. *Pinnæ on large plants acuminate, edges lobed ¼–½ way towards costa, base strongly auricled above and less so below; lobes close, usually irregular in length;* veins pinnate in the lobes, to about 4 pairs, often all fertile, the sori from the costa almost to the edges, the sorus on the lowest acroscopic vein diplazioid, the others not.

This is a very common fern of lowland forest, varying much in size and in the degree of lobing of its pinnæ. Young (or small) plants with blunt entire pinnæ may be fertile. The largest plants approach *D. silvaticum,* but differ in the points mentioned under that species. It approaches also *D. tomentosum,* some specimens having many short hairs, like those of *D. tomentosum,* on the base of pinna-stalks beneath, and to much less extent on the main rachis; but *D. crenatoserratum* is never so tomentose as typical *D. tomentosum.* Typical specimens of the two species are very different, but some are almost intermediate; distinguishing characters are given under *D. tomentosum.*

5. **Diplazium dilatatum** Bl. Enum. 194. 1828.

A very large fern, with stout erect stock. *Stipes* 8 mm. or more in thickness near base, *slightly rough* with raised bases of fallen scales; *scales to about 1·5 cm. long, hardly 1 mm. wide at base, brown with black toothed edges. Lamina bipinnate-tripinnatified, pinnæ to 75 cm. long and 27 cm. wide,* pinnules to about 12–jugate below deltoid lobed apex of pinna. Rachis glabrescent, costæ with scattered very narrow brown scales, especially near base and on stalks of pinnules. Largest pinnules to 18 by 4 cm. (commonly narrower) on stalks 5 mm. long, base truncate-subcordate, apex acuminate, cut half-way to costa or a little more, segments 8–10 mm. wide at base, slightly oblique, edges slightly toothed, apex rounded; smaller distal pinnules sessile, lobed less deeply; texture thin but firm, colour when dry dark. *Veins in each lobe pinnate with 5–8 pairs of veinlets,* lowest acroscopic veinlet often simple, the rest *usually forked* (sometimes simple in fronds of small or young plants), *sori from near base along ½–2/3 length of the veinlets;* sorus on basal acroscopic veinlet usually diplozioid, rest not.

This very fine species has only been found in Malaya at Cameron Highlands. The Highlands specimens closely match a fern from Java (G. Ardjœnœ, 1800 m. Posthumus 3939) and also the Sumatran specimens quoted below. I

think they are quite distinct from the more numerous specimens, mostly from lower elevations, referred in this paper to *D. simplicivenium.*

Specimens in Singapore Herbarium:

PAHANG. Cameron Highlands, 4,600 ft., S.F.N. 23620 (Henderson); S. Terla, 3,900 ft., S.F.N. 31334 (Holttum), young plant.

SIAM. Doi Chiang Dao, Eryl Smith 1198.

SUMATRA. Brastagi, 5,000 ft. S.F.N. 15403 (Holttum). Dolok Singgalang, N. v. h. Tobameer 1650 m., Lorzing 8864.

Copeland Pterid. Philip. Exsicc. 178 (Mt. Matutum, April 1917) seems to me closely similar to the above specimens and I would refer it to the same species.

6. **Diplazium esculentum** (Retz.) Sw. Schrad. Journ. 1801, 2: 312. 1803. *Hemionitis esculenta* Retz. Obs. Bot. 38. 1791.

Stock erect. Stipes to 50 cm. or more long, glabrescent except for a few brown scales at base; scales about 1 cm. long and 1 mm. wide, the edges finely toothed. *Lamina bipinnate, large,* often 1 m. or more long and about half as wide. Pinnæ to 50 cm. or more long, bearing numerous pinnules which are often rather distant from each other. *Pinnules varying much in size and cutting, usually less than 2 cm. wide,* the lowest stalked 2 mm., the rest sessile, *truncate or broadly cuneate and usually more or less auricled on one or both sides at the base, edges crenate or lobed up to about ¼ distance to costa,* the lobes or crenations slightly toothed. Veins in pinnate groups in the lobes, about 8–10 pairs of side veins, *the lower 2–3 pairs of adjacent groups anastomosing,* forming an irregular intermediate excurrent vein leading towards a sinus between adjacent lobes. Texture thin; rachises and costæ glabrescent, or occasionally pubescent beneath with numerous pale brown hairs with dark cross-walls, and scattered or abundant small ovate toothed scales on costæ. Sori occupying almost the whole length of the veins, often also on part of the joint excurrent vein, often more than one diplazioid sorus in each group.

This is a common fern of wet ground in open places in the lowlands of Malaya, and is well known as an edible plant. It never occurs in shady forest. It is a straggling and untidy species, lacking the beauty of most of the larger species of this genus.

The excurrent vein formed by union of the lateral veins of adjacent groups does not run to the sinus, stopping there in a thickened single unit, as in Cyclosorus (Dryopteris p.p.), but divides just below the sinus, part running close

to the edge of the lamina on either side above the sinus. Thus, though the venation of *D. esculentum* is superficially similar to that of species of Cyclosorus, it is not identical and doubtless had a quite separate origin.

7. **Diplazium heterophlebium** (Mett.) Diels Nat. Pfl. 1, 4: 228. 1899. *Asplenium heterophlebium* Mett.; Baker, Syn. Fil. 243. 1867.

Stock short erect. Stipes slender, to 30 cm. long, glabrescent, when young clothed at the base with *thin entire brown scales* to about 1 cm. long and 1·5 mm. wide at the base. *Lamina to at least 35 cm. long and 25 cm. wide, the apical part* (in young plants the whole lamina) *deeply lobed, and below this a few pairs of adnate or sessile pinnæ.* Lobes of apical lamina falcate acuminate entire, to about 15 cm. long and 4 cm. wide; pinnæ to about the same size, their edges entire or more or less deeply undulate. Main lateral veins in the pinnæ pinnate, *the veinlets of adjacent groups anastomosing rather irregularly from about ¼ distance from costa to margin,* the areolæ smaller towards the margin, with free short veins with thickened ends just within the margin. Sori of small fronds few, often one to each vein-group, on the basal acroscopic vein, often all simple but sometimes diplazioid; on larger fronds often several sori to each vein-group, some of them anastomosing with the veins. Texture thin, rachis and costæ glabrous or slightly scaly beneath with small narrow entire scales.

In Malaya, this species has only been found in the valley of the Bertam River, below Cameron Highlands, at 3,000–3,500 ft. altitude. The specimens there gathered differ from Himalayan specimens in having broader fewer pinnæ, all (or almost all) adnate to the rachis, with ampler venation and more irregular anastomosis. It is possible that fully grown plants have not yet been noticed. Further collecting in the valleys in the north of the main range will no doubt reveal more localities for this and other ferns of northern distribution which find their southern limit in Malaya. The thin pale entire scales show that this species is not closely related to *D. accedens,* though the anastomosing venation might lead one to think them allied.

8. **Diplazium insigne** Holttum, Gard. Bull., S.S., 9: 123. 1937.

Stock stout, short, erect. Stipes stout, c. 1 m. long, spiny towards the base, the spines 2 mm. long, each at first bearing a scale; scales dull brown 1·5 cm. long by 1·5 cm. wide at the base, with a narrow black toothed edge, deciduous. *Lamina to 1·5 m. long, bipinnate.* Lowest pinnæ about 28 cm. long and 6·5 cm. wide, narrowed and

stalked at the base, the margins lobed half-way to the costa, the apex acuminate. *Middle pinnæ largest, to 60 cm. long and 16 cm. wide, pinnate; pinnules* slightly oblique, *adnate to the rachis* (the lowest ones narrowly, the upper fully adnate and grading into the lobed apical lamina of the pinna), *to 9 cm. long and 2·3 cm. wide,* cuneate at the base at an angle of about 45° on each side, narrowed gradually from the base and then suddenly at 1·5–2 cm. from the apex, margins slightly serrate; texture firmly herbaceous; *veins anastomosing as in D. accedens.* Sori few or copious, the lowest acroscopic sorus in each vein-group usually diplazioid, and occasionally a few others also.

This species is evidently closely allied to *D. accedens,* and the apex of a frond might pass for that species, but its copious bipinnate form marks it as a quite distinct species. It is evidently similar to *D. Smithianum* from Ceylon, but appears to be much larger; probably both *D. Smithianum* and *D. insigne* are local derivatives of *D. accedens* (or *D. proliferum*).

Since the original description of *D. insigne* was published, I have discovered a collection made by Curtis on Taiping Hills at 2,000 ft. (No. 1352), labelled *D. Smithianum,* which is clearly *D. insigne.* Otherwise no new locality has yet been found for *D. insigne* except the type locality in a valley below Fraser's Hill (Pahang side).

9. Diplazium Kunstleri Holttum sp. nov. **Fig. 2.**

Rhizoma repens? Stipites ad 1 m. longi vel ultra, in sicco olivaceo-straminei, non muricati, basin versus squamis rotundatis peltatis deciduis muniti. Rachides læves, pallidæ, plerumque ad basin pinnarum superiorum proliferæ. Lamina bipinnata, ad 120 cm. longa et 80 cm. lata vel ultra; pinnæ fere 12–jugatæ, infimæ leviter reductæ, superiores in lobos apicis laminæ sensim mutatæ. Pinnæ maximæ c. 65 cm. longæ, c. 25 cm. latæ, in stipitibus 9 cm. longis stantes (stipites pinnarum superiorum sensim breviores). Pinnulæ infimæ inter se 5 cm. distantes; pinnulæ maximæ 16 cm. longæ et 3·5 cm. latæ, stipitatæ 3 mm. vel ultra (ad 8 mm.), basi late cuneatæ vel truncatæ, apici acuminatæ dentatæ, cetera margine lobatæ 2/3 costam versus; lobi leviter obliqui, 5–7 mm. lati, basi dilatati, margine leviter serrati, apice rotundati; costulæ falcatæ, squamis parvis latis peltatis paucis munitæ; venulæ in uno lobo 7–9–jugatæ, obliquæ, plerumque furcatæ (vel in pinnulis parvis simplices), utrinque distinctæ sed haud prominentes; lamina textura quam species affines crassior. Sori medium venularum solum occupantes; indusia angusta, in soris maturis haud evidentia.

Typus: Ginting Simpah, Selangor, 2,500 ft. alt., S.F.N. 31194, leg. Holttum.

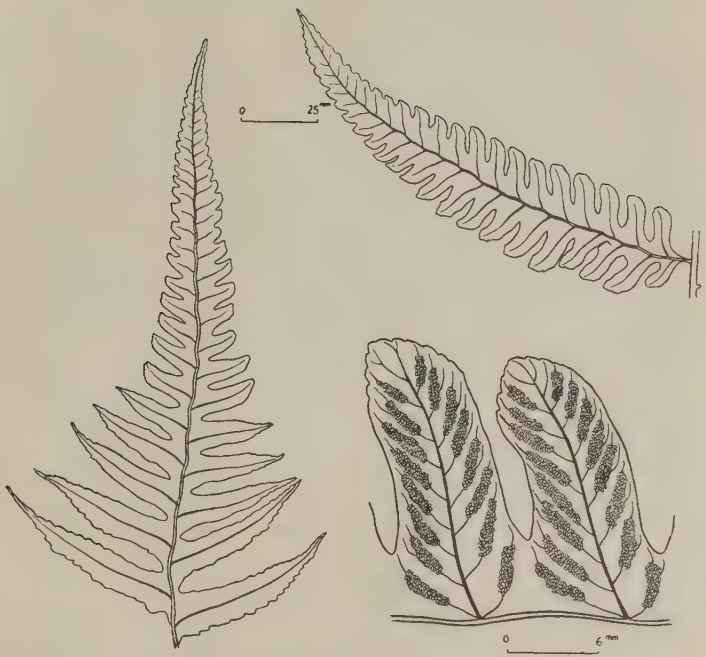


Fig. 2. Diplazium kunstleri, type. On left, apex of frond; on right, above, single pinnule from middle pinna; below, two fertile lobes.

D. Kunstleri is very distinct among the Malayan bipinnate species of Diplazium in the combination of the following characters: round peltate scales (otherwise found only in *D. latisquamatum*) ; pinnules cut more than half-way to the costa, with broad lobes; medial sori which never reach base or apex of the veins; and proliferous rachis. I found the type growing in a rocky streambed in shady forest.

The species is named after Hermann Kunstler ("King's Collector" of herbarium labels), who collected many interesting Malayan plants for the first time. He collected *D. Kunstleri* "near little stream, dense jungle", near Ulu Kerling, under No. 8797. Other collections in the Singapore herbarium are: 15th mile, Pahang Track, Ridley 8652; Rawang, Ridley 7843, 7852. Thus all specimens have been found on the Main Range in Selangor, at medium altitudes.

10. Diplazium latisquamatum Holtt. Gard. Bull., S.S., 9: 124. 1937. **Fig. 3.**

Stock short erect. *Stipes* to 90 cm. long, *throughout or towards base only papillate with rather soft green papillæ,* which in young fronds bear *round or ovate, peltate, entire, nearly black scales, to about 5 mm. long and 3 mm. wide;* old stipes and rachises bearing scattered small rounded scales only. *Lamina* to about 1·5 m. long and 1 m. wide, *bipinnate-tripinnatifid.* Largest pinnæ to about 60 cm. long and 23 cm. wide, shortly stalked, the basal pinnules slightly reduced, smaller on the acroscopic than on the basiscopic side. *Pinnules sessile* (or the basal ones on stalks to 2 mm. long), the largest about 12 × 2·5 cm. (*commonly* about 9 × 1·5 cm.), base broadly cuneate or subtruncate, gradually narrowed to acuminate toothed apex, *margins lobed to within 2–3 mm. of the costa,* lobes slightly oblique, mostly about 4 mm. wide, apex truncate, margins entire or slightly toothed near apex, texture thin but firm, costæ bearing scattered small ovate or rounded scales; veins pinnate in the lobes, the veinlets 5–6–jugate, simple or forked. *Sori occupying only the lower half or less of the veins,* the basal acroscopic sorus usually diplazioid, the others simple, the indusia thin, broad, persistent.

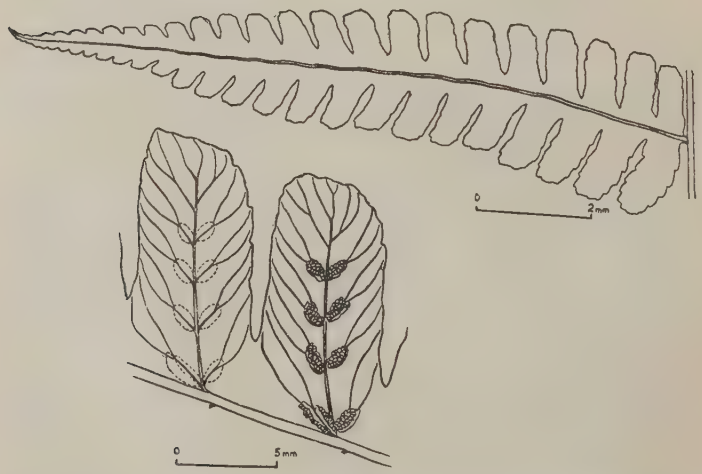


Fig. 3. Diplazium latisquamatum. Above, single pinnule from middle pinna. Below, two fertile lobes; the dotted outlines on the left hand lobe show the position of sori removed.

This species is very clearly distinguished from all others in Malaya by its almost round peltate entire scales and very short sori confined to the basal half of the veins. In general appearance, it resembles *D. procumbens,* but the scales of the latter, and its prostrate stem, distinguish it, even in sterile plants.

D. latisquamatum has been found in Malaya in shady forest by streams in the valleys of the Main Range at 4,000–5,000 ft. at Cameron Highlands and Fraser's Hill only. I have collected closely similar specimens in Sumatra, at 6,000–7,000 ft. altitude on Korinchi Peak. I am, however, in some doubt whether the Kinabalu (British North Borneo) specimens cited with the original description of the species should be regarded as identical; some have decidedly longer and more pointed scales, and pinnæ and pinnules broader.

The additional specimens from Malaya and Sumatra to be added to the list published in 1937 are:—

PAHANG. Fraser's Hill, 4,000 ft. S.F.N. 11007 (Md. Nur); S.F.N. 36504 (Holttum).

SUMATRA. Korinchi Peak 6,000–7,000 ft., Holttum s.n. 13/2/1933.

11. Diplazium malaccense Presl. Epim. Bot.: 86, 1849

Stock short erect. *Stipes* to c. 50 cm. long, *clothed at base with entire brown scales which are 10–15 mm. long and 1·5–2 mm. wide at base, rest of stipe and rachis glabrescent, not fibrillose. Lamina pinnate,* to about 60 by 30 cm. Pinnæ to about 20–jugate, below lobed apex of the lamina. *Lower pinnæ on stalks 5 mm. long, bases very unequal,* lower base often much cut away, upper truncate; upper pinnæ with base subequally truncate or broadly cuneate. *Pinnæ thin in texture, drying rather light green, commonly to 16 cm. long and 2 cm. wide,* apex acuminate, *lobed not more than 2/3 way to the costa,* lobes about 6 mm. wide at the base, a little more oblique than in *D. sorzogonense,* ends rounded to subtruncate and slightly toothed; veins up to 7 pairs in each lobe, all simple; sori from near base of veins to near margin of lamina, the acroscopic basal sorus usually but not always diplazioid. *Surface not depressed below sori;* indusium medium brown, thin but firm, usually turned back but not rolled as in *D. sorzogonense.*

A species of lowland and midmountain forest, found throughout Malaya, differing from *D. sorzogonense* (which grows in similar localities) in glabrescent stipe and rachis, less deeply lobed pinnæ, and sori not at all impressed. Specimens have been distributed under the names *D. silvaticum* and *D. speciosum,* both of which differ in having toothed scales.

A very large, perhaps monstrous, specimen was gathered by Mohamed Nur on Gunong Angsi (S.F.N. 11563). The apical part of the frond is quite like normal *D. malaccense,* but the middle and lower pinnæ are very large (to 8 cm. wide) and deeply lobed (almost to the costa), the lobes being falcate and acutely pointed, with forked lateral veinlets up to about 20 pairs. The bases of these pinnæ have 3 or 4 pairs of normal segments below the larger pointed segments.

12. Diplazium montanum v.A.v.R. Bull. Buitenz. II Ser., 28: 19. 1918.

Stock short erect. *Scales* on bases of stipes *narrow, black, entire,* to about 10 by 1 mm. Stipes black at the base, to about 60 cm. long. *Frond simply pinnate. Pinnæ* to about 20–jugate, *to about 18 by 2 cm.,* the lower ones on stalks to 4 mm. long, upper sessile, *the apical pinna like the others* (occasionally with one or two ± separate round lobes at the base); upper pinnæ unequally cuneate at the base; *lower pinnæ with upper base narrowly rounded, lower base narrowly cuneate; edges of pinnæ toothed,* apex acuminate toothed, texture thin; *veins forked at or near base,* the acroscopic branch soriferous, simple, *the lower branch simple or sometimes forked,* occasionally bearing a short sorus. Sori on the acroscopic veinlet mostly simple, but occasionally diplazioid, reaching from the costa almost to the edge of the lamina.

This species differs from *D. pallidum* Bl. in having the apical pinna like the others (in *D. pallidum* the apical lamina of the frond is deltoid and deeply lobed), and in having the lower pinnæ with much narrower bases (in *D. pallidum* the lower pinnæ have a broadly truncate upper base). It appears also that *D. pallidum* has fertile fronds from a young stage of development, whereas *D. montanum* does not produce fertile fronds until the plants are full grown.

D. pallidum occurs in Sumatra on the higher parts of the mountains, matching Java specimens exactly; *D. montanum* appears to occur at lower levels in Sumatra, thus falsifying its name. In the Peninsula *D. pallidum* does not occur. *D. montanum* occurs in forest at low and medium elevations.

Specimens in Singapore Herbarium:—

PAHANG. Tahan River, Ridley 2167. Tembeling, S.F.N. 24703 (Holttum). Buloh Telang, P. Tioman, 800 ft., S.F.N. 18583 (Henderson).

PERAK. 2,000–2,500 ft., King's Collector 10959. Sungei Siput, Haniff 4047. Ulu Temango, Ridley 14209.

SUNGEI UJONG. Hullett s.n. Aug. 1880.
SELANGOR. Batu Caves, Ridley 8139.
SUMATRA (East Coast). Region of Marban, Bilah, near Bilah Pertama, Rahmat si Toroes 145,221 (distr. Univ. of Michigan).
SIAM. Patani, 210–350 m., on rock in stream, Eryl Smith 1948.

13. **Diplazium polypodioides** Bl. Enum. 194. 1828.
D. asperum Bl. Enum. 195. 1828.

Stock stout, erect, often subarborescent; stipes stout, to 1 m. long, clothed thickly at the base with *narrow scales of thick texture, dull brown with narrow black toothed edges,* to about 4 cm. long and 2 mm. wide at base, usually not more than 1 mm. wide over the greater part of their length; *the scales attached to protuberances on the stipe which remain as more or less short prickles* up to 1 mm. or rather more in height. *Lamina bipinnate,* deeply tripinnatifid, *commonly about 100 cm. long and 60 cm. wide,* sometimes much larger, largest pinnæ to about 85 by 30 cm., commonly less, shortly stalked, with 20–30 pairs of pinnules below the deltoid lobed apex of the pinna. Largest pinnules to 16 by 3·5 cm., commonly about 9 by 2 cm. or sometimes less, sessile or the lowest shortly stalked, base truncate or very broadly cuneate, apex acuminate, *edges cut into lobes ¾ or more towards the costa;* lobes slightly oblique, subtruncate or bluntly pointed, their *margins sharply toothed throughout, 2–5 mm. wide,* veins 7–12 pairs in each lobe, usually simple, forked in the largest lobes; texture thin to firm. Rachises and costæ usually glabrescent, the costæ sometimes with small narrow scales; rachises, like the stipes, often slightly prickly with the bases of fallen scales. Costæ above distinctly winged, the wing interrupted and sometimes dilated at the base of each costule. Sori usually present on almost all veins, from the base half-way or more to the edge, the indusia thin but persistent; on short narrow lobes with close veins the sori may be almost confluent.

The long narrow black-edged toothed scales, the usually prickly stipes, and the deeply cut narrow toothed lobes are characteristic of this species.

SELANGOR. Klang Gates, F.D. 14602 (Ingram). Ginting Simpah, 1,500 ft., Hume 8551B (Herb. F.M.S. Mus.), S.F.N. 9982 (Burkill).
NEGRI SEMBILAN. G. Angsi 950 ft. S.F.N. 11515 (Md. Nur). Senaling Inas F.R., in small clearing, S.F.N. 9770 (Holttum).
PENANG. N. of Western Hill, 2,000 ft., S.F.N. 19776 (Holttum). Penara Bukit, 2,000 ft., S.F.N.

19342 (Holttum). No loc., abundant, C. Curtis 10135.

PERAK. Ulu Temango, Ridley 14206. Ulu Bubong, King's Collector 10849.

PAHANG. Raub, S.F.N. 14103 (Best). Telom, Ridley 13975. Kuala Tahan, Ridley 2,400. S. Sat, S.F.N. 22089 (Henderson). Robinson Falls, 4,000 ft., S.F.N. 23262 (Holttum). Boh Plantations, 4,000 ft., S.F.N. 32937 (Md. Nur). C. Highlands, 5,000 ft., S.F.N. 23518 (Holttum) S.F.N. 31295 (Holttum) ; 4,800 ft., S.F.N. 23361 (Holttum).

In Malaya, this species is common by the edge of forest in moist ground, especially by streams, never in the heavy shade of high forest. It is especially characteristic of the mountains between 2,000 ft. and 4,000 ft., occurring abundantly by roadsides, but occurs also in low country and at higher elevations. In very moist slightly shaded situations in mountain valleys it sometimes attains a very large size, with broader and thinner leaflets than commonly, but I cannot see any clear specific distinction between these and the smaller leaves of firmer texture. The upper parts of larger fronds are much like the smaller fronds.

I have not examined any Indian specimens, and I do not know how far the specimens described by Beddome as *D. polypodioides* and *D. asperum* would agree with Malayan plants. *D. polypodioides,* as I understand it, is certainly a very widely distributed species. I have seen specimens which I would so name from N. Siam, Hainan, the Philippines and New Guinea.

As regards the identity of Blume's two species, *D. asperum* and *D. polypodioides,* I follow both Raciborski and the recent work of Backer and Posthumus in uniting them, using the name *polypodioides,* though I think it is a pity that the more appropriate name *asperum* was not chosen. Van Alderwerelt van Rosenburgh suggested various differences between Blume's two species, but I do not find that these differences are constantly associated in Peninsula specimens. As above noted, habitat appears to have a considerable influence on size and other characters.

14. **Diplazium Prescottianum** (Wall.) Moore, Index 156. 1859. *Aspidium Prescottianum* Wallich, Catalogue No. 235 (nomen) ; Hooker, Spec. Fil. 3: 251. 1860.

The type of this species was collected in Singapore, and agrees with the other Singapore specimens quoted below. These may be described as follows. *Scales* on bases of stipes *brown, entire, about 1·5 mm. wide at base.* Pinnæ to about

14–jugate below the lobed deltoid apex of the lamina, texture firm. *Lowest pinnæ on stalks to 6 mm. long,* upper sessile or adnate. Lower pinnæ to 24 cm. long and 1·8 cm. wide, base unequal, rounded above, rounded or cuneate below; upper pinnæ with broadly cuneate auricled upper base, and narrowly cuneate lower base. *Edges of pinnæ crenate or slightly lobed, lobes slightly toothed or entire, the auricle at the base of the upper pinnæ more or less separated by a sinus from the rest of the pinna* (in the type with a few similar lobes following it, cut nearly to the costa). *Veins of largest pinnæ in pinnate groups, 3–4 veinlets on each side of the main vein, 4–6 veins in each group soriferous,* sorus on basal acroscopic vein diplazioid, others not; sori from near base of vein to near margin.

The other specimens differ in the width of the pinnæ, which are up to 3·3 cm. wide, and some of them in the entire lack of an auricle on the upper base of the upper pinnæ. All agree in the character of the scales, the stalks of lower pinnæ, the slight lobing or crenation of the edges of the pinnæ, and the number of veins and sori in each group. The species appears to be related to *D. montanum* v.A.v.R. (and *D. pallidum* Bl.), but differs in larger brown scales, more lobed edges to pinnæ, and many more soriferous veins in each group. From *D. subintegrum* it differs in shorter pinna-stalks, more lobed edges, more veins and sori in each group.

Specimens in Singapore Herbarium:—

SINGAPORE. Between Bukit Panjang and Woodlands, Matthew; Toas, Ridley s.n. 1892.

SELANGOR. Ginting Simpah, Hume, F.M.S. Mus. 9665, 9347, 8997, 9677.

PERAK. Kinta, 1,500–2,000 ft., Kunstler 7146. Larut, 2,000–3,000 ft., Kunstler 2391. Kinta, Curtis 3369.

SIAM. Patani, 540–700 m., Eryl Smith 1930; 260 m., Eryl Smith 1927. Koh Chang, Marcan 1268.

15. Diplazium procumbens Holttum sp. nov. **Fig. 4.**

Rhizoma procumbens, c. 1 cm. diametro. Stipites ad 80 cm. longi, in sicco sordides vel straminei, glabrescentes, basibus squamarum deciduarum leviter asperuli, in juventute squamis parvis lineari-lanceolatis, fuscis, margine leviter dentatis (non nigris) vestiti. Lamina deltoidea, bipinnata, ad c. 80 cm. longa et c. 80 cm. lata; pinnæ maximæ 50 cm. longæ et 20 cm. latæ. Pinnulæ sessiles vel infimis stitipatæ (stipites 3 mm. longi), maximæ 2·5 cm. latæ, basi truncatæ, apice acuminatæ, ¾ ad costam lobatæ; lobi maximi basi 7 mm. lati, oblongi, cum costa angulum fere rectum formantes, apice rotundati, margine apicem

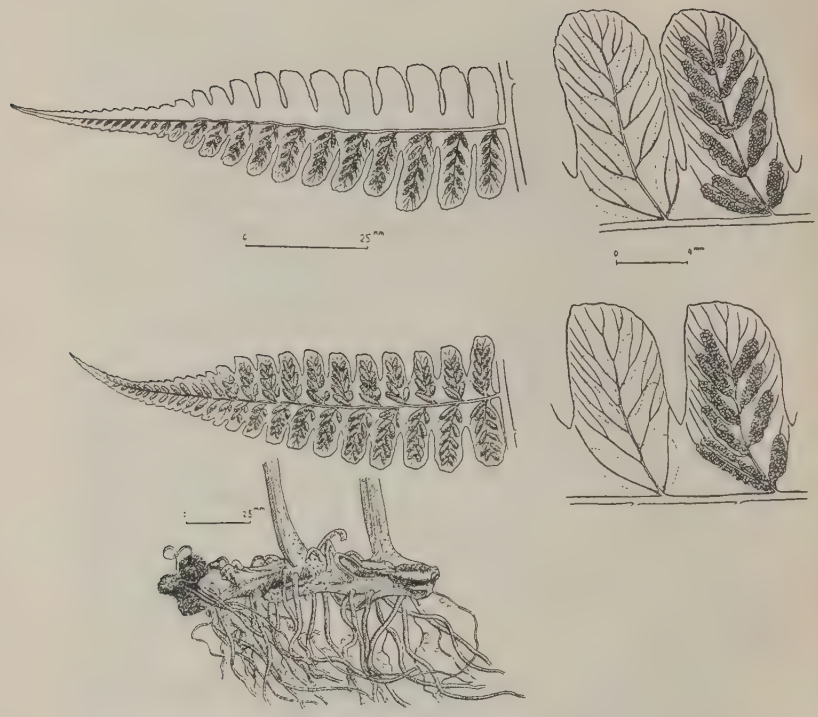


Fig. 4. Diplazium procumbens. On left, pinnules from different fronds, and on right enlarged portions of each to show veins and sori. Below, the procumbent rhizome.

versus leviter dentati. Venulæ ad 7–jugatæ, in lobi maximi omnes furcatæ, in lobi parvi plerumque simplices, costæ squamulis paucis parvis lanceolatis brunneis dentatis munitæ. Sori e costa in ½–2/3 longitudine venularum sedentes, sorus infimus acroscopicus plerumque diplaziodeus; indusia tenuia membranacea.

TYPUS: Fraser's Hill, 4,000 ft., S.F.N. 36503 (Holttum).

This species resembles *D. latisquamatum* in appearance, but differs in its narrow slightly toothed scales (round and entire in *D. latisquamatum*), procumbent rhizome, hardly muricate stipes, usually broader, more acuminate pinnæ, more copiously forked veins and longer sori with very thin indusia. It is abundant in the moist shady valleys, near streams, on the Pahang side of the divide at Fraser's Hill, and has not yet been found elsewhere.

Specimens in Singapore Herbarium:—
Fraser's Hill, 4,000 ft., S.F.N. 8844 (Burkill & Holttum), S.F.N. 11478 (Holttum), S.F.N. 21645 (Holttum), S.F.N. 37201 (Addison), s.n. Corner 12.8.37.

16. Diplazium riparium Holttum sp. nov. **Fig. 5.**

Rhizoma breve erectum. Stipites ad 50 cm. longi, in vivo virides, in sicco brunnei fusci, basi squamis lanceolatis, fere nigris, integris, 4–5 mm. longis, 1·5 mm. latis, vestiti, cetera nudi. Lamina pinnata, pinnæ laterales ad 5–jugatæ (superiores nonnunquam leviter adnatæ), pinna terminalis

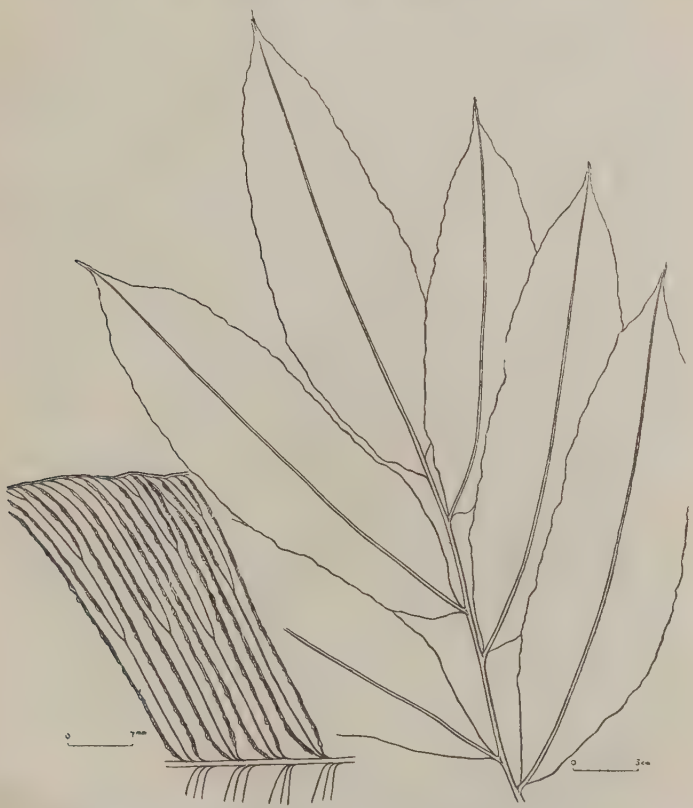


Fig. 5. Diplazium riparium, type; outline of frond. On left, below, detail of venation and sori, enlarged.

ceteris similis, rachis non prolifera. Pinnæ maximæ ad 29 cm. longæ et 7 cm. latæ, brevissime stipitatæ vel sessiles, basi subæqualiter cuneatæ, margine fere integræ, apicem versus subito augustatæ et plus minusve caudatæ, cauda ad 2 cm. longa; costa subtus rotundata, in sicco brunnea vel fusca, nuda, supra in sicco canaliculata; venæ angulum plus quam 60° cum costa formantes, rarissime anastomosantes, in fasciculis parvis glomeratæ; fasciculus ex venis tribus constatus, vena medialis furcata (sæpe bis furcata); sori 3–4 pro fasciculo, sori venarum lateralium e costa fere ad marginem extensi, ceteri breviores, omnes prope marginem terminati.

TYPUS: Selangor, Semenyih, Hume 8186 (Herb. F.M.S. Mus.).

This species agrees with *D. xiphophyllum*, as I understand it, in Malaya, in its entire scales and rather large subentire pinnæ. It differs from *D. xiphophyllum* in the following characters: stipe and rachis darker when dry (stramineous in *D. xiphophyllum*); scales shorter, darker; fronds much shorter; pinnæ to about 5 pairs only, shorter and broader, almost or quite entire on old plants; anastomosis of veins rare, veins at more than 60° to midrib in mature plants, the ends of the veins uniting with a cartilaginous margin; rachis not gemmiparous.

Young plants have the first fronds simple, later fronds with one or more pairs of lateral pinnæ, which have distinctly toothed margins, especially towards apex, fertile from an early stage (on pinnæ from 9 × 2 cm.), the lateral veins often making a smaller angle to the midrib than in the larger pinnæ of mature plants.

This is a fern of the lowlands only, in forest near streams, usually in wet places and often on stream banks. It has also been found in the low country of E. Sumatra and Sarawak. It has usually been referred to *D. bantamense*, from which it differs in its entire scales and lack of buds on the rachis, also in young plants not having hastate or cordate fronds. It also resembles *D. Donianum*, but this also (so far as specimens available indicate) has toothed scales. It may be very near *D. alternifolium* from Java, but appears to differ in more entire pinnæ and in fewer veins in each group (*D. alternifolium* has usually 3 pairs of lateral veins in each group, often all soriferous); I have not seen scales of *D. alternifolium*.

Specimens in Singapore Herbarium:—

PERAK. Upper Perak, 300 ft., L. Wray Jr. 3590 (young), 3650. B.P.D. 300–500 ft., King's Collector 7894.

PAHANG. Near K. Teku, 500 ft. (young plant), S.F.N. 20792 (Holttum); S. Cheka, young plant, S.F.N. 24780 (Holttum); Mentakab, West, S.F.N. 24558 (Holttum).
KELANTAN. Ulu S. Keteh, Md. Nur, s.n. 14.2.24.
TRENGGANU. K. Brang, S.F.N. 15323 (Holttum).
SELANGOR. Semenyih, Hume, F.M.S. Mus. No. 8186 (Type).
MALACCA. Ayer Keroh, Ridley s.n. Dec. 1899. Ayer Panas, Ridley 1587.
SUNGEI UJONG. No loc., Alvins 3282.
JOHORE. Ulu Sedili, Holttum, s.n., May 1932; foot of G. Panti, 200 ft., S.F.N. 18301 (Holttum).
SINGAPORE. Hullett s.n. Jan. 1881.
SUMATRA. East Coast, general region of Marbau, Rahmat si Toroes 222.
SARAWAK. No loc., Bishop Hose s.n., 1890.

17. **Diplazium silvaticum** (Bory) Sw. Syn. Fil. 92. 1806. *Callipteris silvatica* Bory, Voy. 1: 282. 1804.

Stock short, erect. *Scales on young fronds* and bases of stipes *very dark, to about 10 mm. long and 1·5 mm. wide, closely and distinctly toothed, teeth often forked* (*see* fig. 1). Stipes to about 40 cm. long. Frond simply pinnate, to about 50 by 20 cm., pinnæ numerous, lower stalked to about 5 mm., upper sessile; *lowest pinnæ with upper base subtruncate, lower base cuneate; upper pinnæ with base broadly cuneate to truncate, more or less auricled above but not below;* pinnæ to about 12 cm. long and 3 cm. wide (commonly less), apex acuminate, *edges lobed to about ¼ distance to costa, texture thin;* lobes oblique, about 5 mm. wide, veins in pinnate groups with 3–4 pairs of lateral veins; sori from near base of veins ¾ or more towards edge, sorus on acroscopic basal vein diplazioid, sometimes sorus on next acroscopic vein also, other sori simple.

This species, which I believe I have correctly identified, occurs throughout Malaya, but is not always easy to distinguish from *D. crenatoserratum*. It differs from *D. crenatoserratum* in having broader pinnæ of thinner texture, not auriculate on the lower base, and by the larger and closely and distinctly toothed scales, the teeth often forked. Some specimens approach *D. malaccanum* in appearance; they are distinguished by their toothed scales (scales of *D. malaccanum* are entire).

D. silvaticum was originally described from Mauritius. Malayan specimens, according to Christensen (Dansk Bot. Ark. 7: 82. 1930), are very close to the type. This must be reckoned one of the most widely distributed species of the genus. Ceylon specimens in the Singapore herbarium

have scales like Peninsula plants, but have more ample fronds than any Malayan specimens. How far eastwards the species extends, I do not know. A Java specimen in the Singapore herbarium (quoted below) agrees quite well with Peninsula specimens.

Specimens in Singapore Herbarium:—

SINGAPORE. Hullett s.n. (2 sheets).

PAHANG. Tahan River, Ridley 5818. S. Cheka, Holttum s.n., 26.4.31. Tembeling, S.F.N. 24704 (Holttum). Base K. Glanggi, S.F.N. 22422 (Henderson).

SELANGOR. Woods Batu Caves, Ridley s.n., Dec. 1891 (?). Klang Gates, F.M.S. Mus., Hume 7117.

PERAK. Upper Perak, 300 ft. Wray 3626, 3594. Gapis Pass, Curtis 1360.

KELANTAN. Gua Panjang, Gua Ninik, S.F.N. 19498 (Henderson).

KEDAH. Langkawi, G. Raya, Curtis s.n., Sept. 1890. 48 mile Jeniang Road, S.F.N. 35995 (Kiah).

JAVA. Djember, inter G. Boto et Tjuramamis, 600 m., Backer & Posthumus s.n. 11.3.29.

SIAM. Chawng (7° 35′), S.F.N. 24382 (Kiah, doubtful). Betong, Patani, 440 m., Eryl Smith 1929.

18. **Diplazium simplicivenium** Holttum sp. nov. **Fig. 6.**

Rhizoma breve erectum. Stipites 1 m. longi vel ultra, basin versus basibus squamarum deciduarum asperuli; squamæ 2 cm. longæ vel ultra, prope basin 1–2 mm. latæ, fuscæ, marginæ dentatæ, dentes simplices. Lamina 1·5 m. longa et 1 m. lata vel ultra, bipinnata. Pinnæ adjacentes c. 15 cm. inter se distantes, obliquæ; pinnæ maximæ 65 cm. longæ et 20 cm. latæ; pinnulæ liberæ ad 20–jugatæ, sub apicem lobatum laminæ; pinnulæ maximæ 12 cm. longæ, 2 cm. latæ, fere sessiles, basi truncatæ (non auriculatæ), apicem versus acuminatæ, e margine ¼ costam versus lobatæ; lobi truncati, c. 7 mm. lati, leviter obliqui; venæ c. 5–jugatæ, omnes simplices; sori e basi venarum ¾ vel ultra marginem versus extensi; textura laminæ tenuis, venæ utrinque distinctissimæ; costæ subtus (plerumque basin versus) squamis parvis paucis brunneis, margine fere nigris, munitæ.

TYPUS: Fraser's Hill, 4,000 ft. alt. S.F.N. 36507, leg. Holttum.

This species differs from *D. dilatatum* in the following characters: wider and longer scales of coarser texture; veins all simple (some may be forked on transition pinnæ near apex of frond, but none on the typical larger pinnæ, even

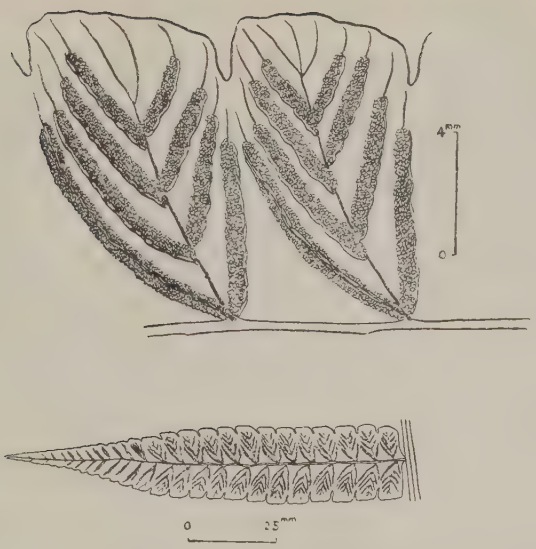


Fig. 6. **Diplazium simplicivenium.** Below, single pinnule from large pinna. Above, two lobes enlarged to show venation and sori.

of very large fronds); usually not more than 5 pairs of veins; sori occupying ¾ or more of the length of the veins.

D. simplicivenium occurs in moist shady valleys near streams; it has been found on the Main Range, the Taiping Hills, and on G. Senyum in Pahang, also in Lower Siam. Some specimens from Borneo agree in having simple veins, but they have much wider pinnules than Peninsular specimens and I doubt their identity with this species.

Specimens in Singapore Herbarium:—

PERAK. No loc. Hullett s.n., 1881. Larut, 1,000–1,500 ft., King's Collector 2346; 1,500–2,000 ft. King's Collector 2214. Temango, Ridley 14211. G. Bubu, 600–800 ft., King's Collector 8420.

PAHANG. Tras Valley, 3,800 ft., S.F.N. 21636 (Holttum). Base of G. Senyum, S.F.N. 22388 (Carr).

SELANGOR. Ginting Simpah, Hume 9110 (F.M.S. Mus. Herb.).

LOWER SIAM. Khaw Poh Hill, Khsum, 1,200 ft., S.F.N. 3829 (Haniff & Nur).

19. Diplazium sorzogonense Presl, Tent. Pterid.: 114. 1836 *Asplenium sorzogonense* Presl, Rel. Hænk. 1: 45. 1825.

Stock short erect. Stipes to c. 60 cm. long, scaly at base *with long narrow entire scales,* scales dark brown, sometimes with black edges, to about 1·5 cm. by 1·5 mm.; *rest of stipe and rachis scaly with very narrow dark hair-like scales.* Lamina simply pinnate, to about 80 by 40 cm., pinnæ to c. 20–jugate below pinnatifid apex of frond; *lower pinnæ very shortly stalked,* upper sessile, bases truncate or subtruncate, apices acuminate, margins lobed ¾ or more *to costa in lower pinnæ,* less deeply in upper ones; *lobes almost at right angles to costa,* oblong, ends rounded and slightly toothed, 4–6 mm. wide above base; texture firm, *drying rather dark;* largest pinna to 25 × 5 cm., commonly less, *veins in the lobes to about 10 pairs, all simple,* basal ¼ usually free of sori; sori reaching almost to margin, *the lamina below the sorus depressed, the depression with a distinct margin on the dried frond.* Sori usually all simple near the base of a pinna, the acroscopic basal sorus of each lobe diplazioid towards apex of pinna. Indusia firm, persistent, rolled back when sorus is mature.

This species is found throughout Malaya, in lowland and mountain forest to 4,500 ft. altitude. It is a very widely distributed species, and though somewhat variable is always recognizable by the fibrillose stipe and rachis and the peculiar impressed sori, which I have not found in any other Diplazium of this region (except slightly in *D. subserratum*).

D. sorzogonense differs from *D. speciosum* in having entire scales, fibrillose rachis, and in the impressed sori. I think that the two species have sometimes been confused.

Specimens in Singapore Herbarium:—

SINGAPORE. Stagmount, Ridley s.n., 1907; Ridley 11271. Bukit Timah, Ridley s.n. 1897. Mandai Road, Corner s.n., 20.10.29.

PERAK. Kinta, 1,500–2,000 ft., King's Collector 7151. Taiping, Scortechini, March 1884. Tapah, Ridley 14023.

SELANGOR. Kwang, Ridley 13432.

PAHANG. Fraser's Hill, 4,000 ft., S.F.N. 11198 (Md. Nur); s.n., Holttum 20.3.29; s.n., Holttum 31.12.39. Cameron Highlands, 4,500 ft., s.n., Holttum 21.5.36. G. Rokam, P. Tioman, 2,000 ft., S.F.N. 18612 (Henderson).

PENANG HILL s.n. Dec. 1881, Hullett. S.F.N. 19302 (Holttum).

KEDAH. G. Lang 2,000 ft., S.F.N. 35012 (Kiah).

20. **Diplazium speciosum** Bl. Enum. 193. 1828.

Stock short erect. Stipes to 60 cm. long, clothed at the base with *shining brown scales with toothed but not blackened edges, about 1·5 cm. long and 1·5 mm. wide at base; rest of stipe and rachis glabrescent.* Lamina pinnate, to about 70 × 25 cm., pinnæ to about 20–jugate, to 20 cm. long and 3·5 cm. wide, lower pinnæ on stalks to 4 mm. long, upper sessile, base truncate (on lower pinnæ sometimes narrow), apex acuminate, *margins lobed more than ¾ way to costa in lower pinnæ;* lobes 4–5 mm. wide above base, slightly oblique, oblong, ends rounded, edges shortly toothed, texture firm, drying rather dark brown; *veins to 10 pairs in each lobe, simple, sori from base of veins over 2/3 their length, not impressed,* often all simple, the *indusia thin but firm, not rolled back when sorus is ripe.*

In Malaya this species has only been found on G. Tahan, specimens from which differ from Kinabalu specimens in wider lobes of the pinnæ; Peninsula specimens agree however with that from Mt. Dulit, Sarawak, quoted below.

D. speciosum has much the general appearance of *D. sorzogonense,* but lacks the fibrillose scales on stipe and rachis, has toothed scales at the bases of the stipes, and has sori not impressed. The lobes of the pinnæ are also rather more deeply cut and more strongly toothed.

Specimens in Singapore Herbarium:—

PAHANG. Gunong Tahan, Ridley 15991; 5,000 ft., Haniff & Nur. S.F.N. 7953; 4,500 ft., S.F.N. 20747 (Holttum).

BORNEO. Dulit, C. Hose, Herb. Bishop Hose. Kinabalu, 5,000 ft., S.F.N. 25444 (Holttum).

Var. major (Bedd.) Holttum **stat. nov.**
D. sorzogonense v. *major* Bedd. Suppl. 40. 1892.

Differs from the typical form of the species in having fronds to 1·50 m. long, pinnæ to 6·8 cm. wide, the lobes more acute and more strongly toothed, veins to 13 pairs, mostly forked.

PERAK. G. Bubu, 5,000 ft., King's Collector 7403 (type of variety); G. Bubu, 5,000 ft., Wray 3862.

PAHANG. Pine Tree Hill, 4,500 ft., S.F.N. 36508 (Holttum).

SUMATRA. G. Sibayak, 5,000 ft., S.F.N. 15457 (Holttum).

The type of Beddome's variety clearly belongs to this species and not to *D. sorzogonense.* It is a very fine fern and might perhaps rank as a species.

21. Diplazium subintegrum Holttum, Gard. Bull. S.S. 9: 125. 1937.

Stock short erect. *Scales on stipes brown, entire, to* about 1·5 cm. by 2 mm. Stipes to 80 cm. long, pale when dry. *Frond simply pinnate,* to about 70 cm. long; pinnæ to about 16 pairs, *the apical lamina narrowly deltoid, lobed at* the base. *Pinnæ to 24 by 2·5 cm., lowest stalked to 1·5 cm.,* upper 2 or 3 pinnæ only sessile; bases almost equal, of lower pinnæ narrower, cuneate; *edges toothed,* apices acuminate. Veins forked near the costa, the upper branch always simple, *the lower branch forked 1–4 times;* sori on upper branch from base 2/3–¾ of way towards margin, diplazioid, usually also on one branch only of the lower vein, simple.

A mountain species, related to *D. montanum* and *D. pallidum,* differing from the latter in larger brown scales, longer stalks and narrower bases of pinnæ, more branched veins and normally diplazioid sori; differing from *D. montanum* also in the narrowly deltoid lobed apex of the lamina. This species appears to be confined to the Main Range of the Malay Peninsula and the Taiping Hills, at 3,000–5,000 ft. The specimens in the Singapore Herbarium were cited with the original description quoted above; no more have since been acquired.

22. Diplazium subserratum (Bl.) Moore, Index 338. 1862. *Asplenium subserratum* Bl. Enum. 174. 1828.

Stock slender, erect or decumbent. *Stipes slender, clustered,* 10–20 cm. long, glabrescent, clothed when very young with small very dark scales, 2–3 mm. long and less than 1 mm. wide, the edges very shortly toothed. *Lamina simple, to about 50 cm. long and 4 cm. wide,* narrowed gradually to the base which is suddenly contracted from a width of a few millimetres, and very gradually to the acuminate apex; margins entire or irregularly undulate, toothed towards apex; texture very firm. Midrib grooved above, prominent beneath and bearing scattered dark brown ovate–lanceolate scales 1 mm. long or less; scales also on some of the lateral veins beneath. Veins in small groups at an angle of about 60° to the midrib, the groups about 5 mm. apart. Each vein-group formed by forking at the midrib, the acroscopic branch being simple and the lower forked 2–4 times again; the simple acroscopic branch usually soriferous and often one, more rarely two, branches of the basiscopic vein also. Sori on acroscopic vein diplazioid, varying in length, often from the base almost to the edge of the lamina; other sori simple and shorter; indusia firm,

persistent, when old rolled back as in *D. sorzogonense*, and leaving a faint mark on the lamina to show their size and position when young.

This species in Malaya is confined to moist shady mountain valleys, near streams. It is the only Malayan species with narrow simple fronds, and so is easy to recognize. Young plants have fronds which are dissected to the midrib, indicating a probable origin from a pinnate ancestor. The resemblance of the indusia to *D. sorzogonense* is interesting.

D. subserratum is probably allied to *D. lanceum* of India and China, but is larger, and has a shorter rootstock which is more or less erect with tufted fronds; the scales also appear to be smaller.

23. Diplazium tomentosum Bl. Enum. 192. 1828.

Stock short, erect. *Scales* on stipes *to about 4 mm. long and ½ mm. wide, acuminate, dark to medium brown, the edges irregular but hardly toothed.* Stipes to c. 40 cm. long, *frond to about 35 by 15 cm.*, pinnæ many, lowest shortly stalked (to 3 mm.), upper sessile or adnate; *lowest pinnæ largest, somewhat deflexed and curved, widest 1/3 from base, base narrow, apex acuminate, to 3 cm. wide; middle and upper pinnæ narrower, with parallel sides, almost at right angles to rachis,* slightly curved, base truncate, auricled above, broadly cuneate below. *All pinnæ of large fronds deeply lobed* (half way or almost to the costa), *lobes c. 3 mm. wide above the base, at an angle of less than 60° to the costa,* their edges slightly toothed at the tip. *Veins* pinnate in the lobes, the veinlets usually forked, *up to 7 pairs or more, often all or almost all veins soriferous,* the lowest acroscopic vein with sorus directed towards the main costa or diplazioid. Texture firm, drying very dark; *rachis and costæ beneath densely covered with short multicellular hairs with pale cells and dark brown cross-walls.*

Young plants have almost entire pinnæ; these approach *D. crenatoserratum* in appearance but are distinguished by their more hairy rachis and costæ beneath, usually narrower more pointed pinnæ, more deflexed, shorter-stalked lowest pinnæ which are broadest near the middle, and darker colour on drying. Fully developed plants, with their deeply lobed pinnæ and deflexed almost elliptical lowest pinnæ are quite distinct.

D. tomentosum is closely related to *D. velutinum*, a mountain plant with more deeply dissected, though hardly larger fronds. The tomentum of both is of the same character.

D. tomentosum is a common species in lowland and mid-mountain forest throughout Malaya; it seems unnecessary to enumerate all the many specimens.

24. **Diplazium velutinum** Holttum Gard. Bull. S.S. 9: 126. 1937.

Caudex short erect. *Stipes* to 40 cm. long (commonly about 20 cm.), *clothed throughout with scattered multicellular brown hairs,* and towards the base with narrow almost black entire scales, scales to about 1 cm. long and barely 1 mm. wide at the base. *Lamina bipinnate, to about 25 cm. long* and 15 cm. *wide, the rachises and costæ beneath densely clothed with brown hairs* like those on the stipe, with a few small narrow scales. Free pinnæ 12–15 pairs, the sub-basal largest, the upper ones gradually reduced and grading into the lobed apical lamina. *Largest pinnæ c. 8 cm. long and 3 cm. wide* (commonly about 6 by 2 cm.), subsessile, narrowed from truncate base to acute or acuminate apex, *pinnate towards the base only,* for the rest lobed almost to the costa, the pinnules or segments at right angles to the pinna-rachis at the base, gradually more oblique towards the apex. Free pinnules few, the rest more or less broadly adnate to the pinna-rachis; *largest pinnules about 12 mm. long and 4 mm. wide, base unequally cuneate, margins serrate or lobed* as much as half-way to the costule, apex rounded, texture very firm. Veins in pinnules or pinna-lobes 7–10–jugate, mostly forked; sori on basal ½–2/3 of veinlets; in the largest pinnules several diplazioid sori, in smaller pinnules only one such sorus; indusia thin, broad, persistent.

This species, closely related to *D. tomentosum* but much more deeply dissected, has hitherto only been found in the moist shady valleys at Cameron Highlands, 4,800–5,000 ft. above sea level. No further collections have been made since my paper above quoted.

25. **Diplazium xiphophyllum** (Baker) C. Chr., Ind. Fil. 241. 1905.

Asplenium xiphophyllum Baker, J. Bot. 1879: 40.

Stock short, erect. *Stipes to 70 cm. long, drying pale,* clothed at the base with *dull brown entire scales to 1·5 cm. long and 2 mm. or more wide* at the base. Lamina simply pinnate; *pinnæ in adult plants to 12 pairs,* terminal pinna like the rest, *texture thin, colour light green when fresh, light brownish when dry;* lower pinnæ on very short stalks (2 mm. long), uppermost slightly adnate to rachis, *with buds sometimes in their axils. Largest pinnæ to about 35 by 6 cm.,* elliptical, narrowed gradually to the slightly unequal base and more abruptly to the acuminate-caudate

apex; *edges slightly and irregularly toothed throughout;* midrib pale, prominent and glabrous beneath, *lateral veins in small groups, at 45° to the midrib,* commonly of one basal pair and one central vein which is forked, one or both of its branches also forked; *veins occasionally anastomosing near margin but never copiously anastomosing, ending distinctly within the margin* and not united to it. Sori on basal pair of veins in each group, from near midrib to near margin, on other veins shorter, commonly 3–4 sori on each vein-group, the sorus on the anterior basal vein only diplazioid.

The above description applies to ferns found in the Malay Peninsula. The type of the species *D. xiphophyllum* is from Borneo (Labuan, coll. Burbidge, at Kew), and shows a frond of a young plant with narrow pinnæ, and detached pinnæ from a mature plant, these being 30 by 3 cm. There is therefore some doubt whether the Peninsula plant (matched also by the Kinabalu specimens quoted below) is really this species, more especially as young plants from Malaya have quite broad pinnæ. I do not, however, know any other species to which our fern could be referred.

D. xiphophyllum, as here interpreted, is a fern of lowland and mid-mountain valleys, the highest altitude recorded in Malaya being 3,000 ft. It is fairly constant in character, differing from *D. riparium* in its much larger size and in other points mentioned under that species. There is one aberrant collection, that of Burkill from Ulu Chineras, which has long narrow pinnæ (to 3·8 cm. wide), long acuminate with edges more deeply toothed than normally, the vein-groups less branched and without anastomosis, and fewer sori in each group.

Specimens in the Singapore Herbarium:—

SIAM. Patani, 160–350 m., Eryl Smith 1922; Khao Rum, Eryl Smith 618.

PERAK. No loc., Herb. Mus. Perak 234; Jor Camp, Henderson F.M.S. Mus. 10833; Waterloo, Curtis 1361 p.p.; Larut, 3,000 ft., King's Collector 2698; Temango, Ridley 14227.

PAHANG. Ulu Chineras, K. Lipis, S.F.N. 15692 (Burkill).

SELANGOR. Ginting Peras, Ridley 7833; Ginting Simpah, 2,000 ft., S.F.N. 34310 (Md. Nur), 1,500 ft., Hume 8782, 8777, 8542; Kajang, Symington 24200 (F.D.).

BORNEO. Kinabalu, 5,000 ft., Clemens 29406; 3,500 ft., S.F.N. 25258 (Holttum).

List of Collectors' Numbers Cited

(The figures in brackets refer to the numbers given to the species in this paper)

S.F.N.
3829(18)
7953(20)
8844(15)
9770(13)
9876(2)
9982(13)
10018(2)
11007(10)
11198(19)
11473(2)
11478(15)
11515(13)
11563(11)
14103(13)
15323(16)
15403(5)
15457(20 var.)
15692(25)
17978(2)
18301(16)
18583(12)
18612(19)
19302(19)
19342(13)
19346(2)
19498(17)
19776(13)
20554(2)
20747(20)
20792(16)
21636(18)
21645(15)
22089(13)
22388(18)
22422(17)
23262(13)
23340(2)
23361(13)
23518(13)
23620(5)
24382(17)
24558(16)
24703(12)
24704(17)
24780(16)
25258(25)
25444(20)
31194(9)
31295(13)
31334(5)
32937(13)
34310(25)
35012(19)
35995(17)
36503(15)
36504(10)
36505(2)
36507(18)
36508(20 var.)
37159(2)
37201(15)
Ridley
1587(16)
2167(12)
2400(13)
5818(17)
7833(25)
7843(9)
7852(9)
8139(12)
8652(9)
11271(19)
13432(19)
13975(13)
14023(19)
14206(13)
14209(12)
14211(18)
14227(25)
14229(2)
15991(20)
King's Collector (Kunstler)
2214(18)
2346(18)
2391(14)
2698(25)
7146(14)
7151(19)
7403(20 var.)
7894(16)
8420(18)
8797(9)
10849(13)
10959(12)
Hume (Herb. F.M.S. Mus.)
8551B(13)
7117(17)
8186(16)
8542(25)
8777(25)
8782(25)
8997(14)
9110(18)
9347(14)
9665(14)
9677(14)
Curtis
1352(8)
1360(17)
1361 p.p. (2)
1361 p.p. (25)
3369(14)
10135(13)
Eryl Smith
618(25)
1198(5)
1922(25)
1927(14)
1929(17)
1930(14)
1948(12)
Forest Department
14602(13)
24200(25)
Herb. F.M.S. Mus.
10833(25)
Wray
3590(16)
3594(17)
3616(2)
3626(17)
3862(20 var.)
Haniff
4047(12)
Alvins
3282(16)

CARPET GRASS, AXONOPUS SPP.

By R. B. Jagoe
Botanist, Department of Agriculture, S.S. & F.M.S.

Introduction

For many years the apparent difference between broad-leaved and narrow-leaved forms of *Axonopus compressus,* or Carpet grass, has not been generally regarded as of specific rank, although the names *Paspalum platycaule* Poir. for the broad-leaved form, and *Paspalum compressum,* for the narrow-leaved form, have been used by some persons. The original *Paspalum compressum,* Swartz., is however, undoubtedly the broad-leaved grass.

These two Carpet grasses have now been recognised as distinct species, the broad-leaved form retaining the present name (*Axonopus compressus* Beauv.), while Miss Agnes Chase, an American authority, has defined the narrow-leaved grass as a new species, and named it *Axonopus affinis,* as follows:—

Axonopus affinis, sp. novo.

Ab Axonopo compresso differt: Culmis et stolonibus gracilioribus, laminis augustioribus; spiculis brevioribus, 2 mm. longis, obtusis vel subacutis. (Culms and stolons more slender, leaf-blades narrower; spikelets shorter, 2 mm. long, obtuse or sub-acute).

> "The plants are more tufted than in *A. compressus,* sometimes forming dense mats with short rhizomes, and the flowering culms in such colonies are relatively few.
>
> Stolons slender, the internodes short, and the leaf-blades (usually) not conspicuously shorter than those of the culms, as in *A. compressus.*
>
> Culms erect or geniculate ascending, slender, nodes glabrous (?) sheaths compressed, on the average narrower than those of *A. compressus,* leaf-blades flat or folded, 2 to 6 mm. wide.
>
> Peduncles very slender 1 to 3 within uppermost sheath of flowering culm, finally elongate; racemes 2 to 4; 2 to 10 cm. long, spikelets oblong-elliptic rather more plump than in *A. compressus,* 2 mm. long, 0·8 to 0·9 mm. wide, blunt or abruptly acute. The glume and sterile lemma equal, covering the fruit or slightly pointed beyond it, 4 nerved, mid-nerves suppressed, sparsely silky-pilose at base and summit, and sometimes along the nerves. Fruit pale, 1·7 to 1·8 mm. long, blunt." (Agnes Chase).

History

Axonopus compressus, Beauv., is a native of the West Indies and tropical America, and has spread to Florida and Louisiana in the United States. It was introduced to Singapore about 1895 to 1900, for Ridley refers to *Paspalum*

platycaule in 1903 as "lately established in Singapore", since when it has spread to all parts of Malaya, thriving under light or medium shade.

Axonopus affinis, Chase, is a native of the southern United States, and is common in the southern States from Carolina to Texas. This species was introduced as "Carpet grass" to the Central Experiment Station, Serdang, in 1921, seed being sent to the Department of Agriculture by the late Professor C. V. Piper of the Agronomy Section of the United States Department of Agriculture. It has been distributed to many parts of the peninsula, but has not yet spread widely.

Descriptions

The two grasses are readily distinguished, although the broad-leaved species, *A. compressus*, in some circumstances, such as dry, shady conditions, produces long comparatively narrow leaves, little different superficially from those of *A. affinis*.

The distinguishing characters of the two species as found in Malaya differ slightly from those given by Miss Chase and detailed descriptions will be given below.

As stated above, the plants of *A. affinis* Chase, are more densely tufted than those of *A. compressus* Beauv. The former species is normally more free flowering, and the inflorescence peduncles are usually more elongated or extended.

Leaves.—Growing in the same conditions, the leaves of *A. compressus* are larger than those of *A. affinis*, the blades being much broader, though shorter.

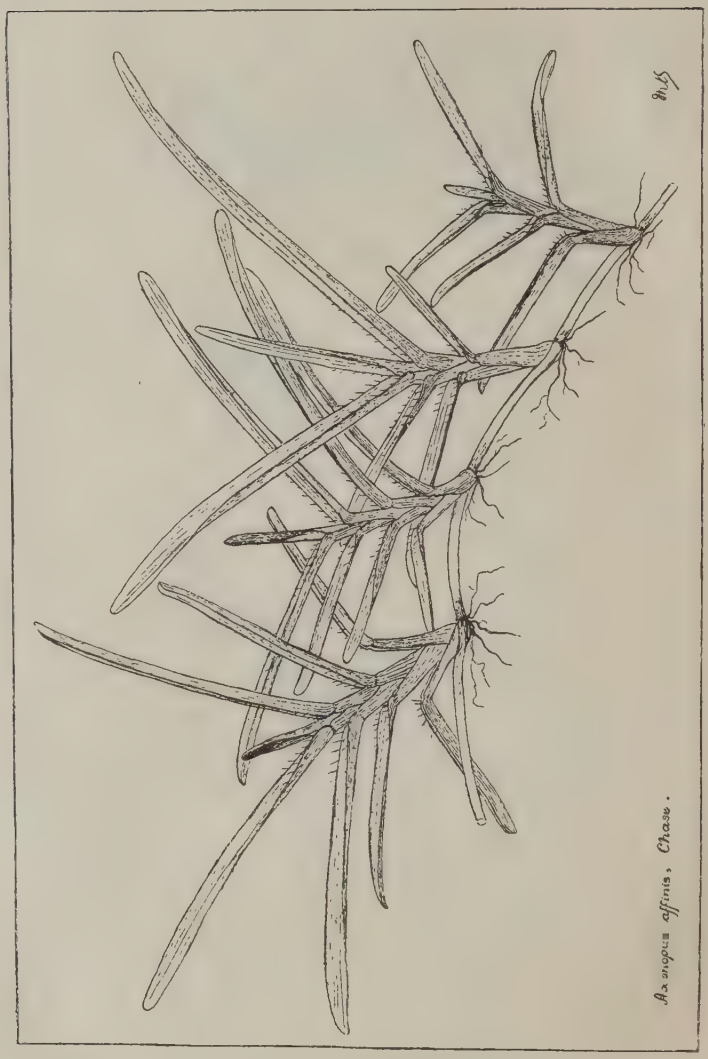
Further distinguishing features are as follows:—

Leaf-blades of *A. compressus* are wavy-edged and bright green, with conspicuous hairy fringes along the edges of the lower three-quarters of the blades. The edges of the sheaths and the ventral surfaces of the blades are hairy, with a few hairs also on the backs of the blades. The blades taper more at the ends and have less blunt-pointed tips.

The leaf-blades of *A. affinis* are longer and stiffer, and are slightly duller green in colour. They are very much less hairy, sometimes hairless, but usually with comparatively few, though long, hairs along the edges of the blades and sheaths, and seldom any on the surfaces of the blades. The edges of the blades are nearly parallel and the tips are blunt. The ends of the leaf-blades in both species are minutely hairy.

The backs of the blades of *A. affinis* are much more prominently keeled, and tend to fold in two, especially when withered or dry.

Axonopus compressus, Beauv.


Andropogon affinis, Chase.

A further point of difference between the two species is that a red coloration in the leaves of *A. compressus* is very common especially in dry exposed situations, but it is extremely rare in those of *A. affinis.*

Stolons.—Both species are freely stoloniferous; stolons vary from fairly slender to comparatively stout, and there is little if any difference between the species in this respect. Stolons are branching; inter-nodes are short, shorter on the average in *A. affinis;* nodes are free-rooting.

In *A. compressus* the stolon nodes are very white-hairy, but in *A. affinis* they are only sparsely hairy.

In *A. compressus* the leaf-blades of the stolon growth stages are often conspicuously shorter than those of flowering culms, while in *A. affinis* this is not so notable.

A. compressus is now fairly common under rubber trees, and there grows most often in tufted fashion, conditions presumably being not very favourable for normal stoloniferous growth.

Flowering Culms.—Every stolon node bears a potential flowering shoot and when circumstances demand or are suitable, shoots from the nodes form flowering culms. At times, small or large leafy colonies of flowering culms are produced on branching rhizomes from the stolon nodes.

The flowering culms proper have only one inter-node, though at times they appear to have two or three. These extra internodes are the result of stoloniferous internodes being formed and assuming a more or less erect attitude, due to the urge to form floral organs coinciding with good conditions for vegetative growth.

The flowering culms develop with the elongation of the basal internode, from the upper node of which and within the final leaf-sheath is a conic "disc" bearing 4 to 6 long bracts each subtending an inflorescence peduncle.

The blade of the uppermost leaf is short, especially so in *A. affinis.*

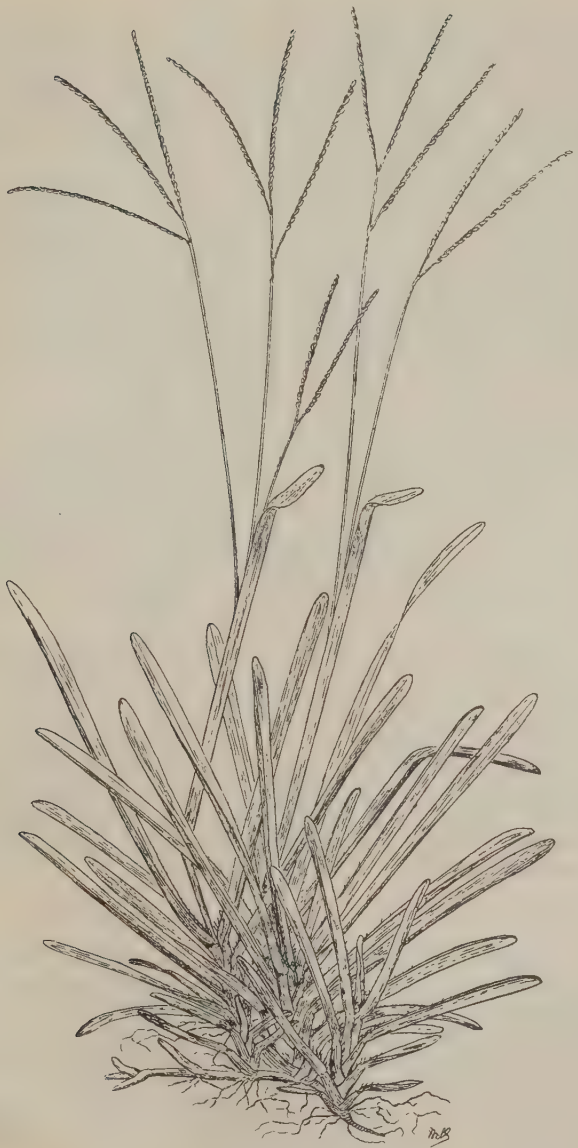
The nodes of the flowering culm are, in *A. compressus,* most usually densely white-hairy, though not always all the way round, while in *A. affinis* only the edges of the compressed nodes are (usually) hairy, but sometimes quite glabrous.

The full details of the morphological differences of the flowering culms are however, more conveniently described by taking each species separately.

Axonopus compressus Beauv. Flowering culms fairly slender, compressed. Nodes more or less silky hairy, leaf-blades 5 to 14 mm. wide, 6 to 28 cm. long; uppermost blade usually short but from 3 to 19 cm. long. From the cone on upper node of culm, 4 to 6 slender peduncles (1 to 4 conspicuous) 10 to 30 cm. long. Very frequently in *A.*

Axonopus compressus. Beauv

Gardens Bulletin, S.S.



Axonopus affinis, Chase

compressus, these inflorescence peduncles remain short, and are not elongated beyond the mouth of the leaf-sheath. Each peduncle bears 2 or 3, rarely 4 to 6 slender racemes, the first two of which are at the apex of the peduncle, one terminal, the second subterminal, with others, when present, alternately at short intervals below. Racemes 4 to 10 cm. long.

Spikelets usually silky hairy, not closely spaced, alternating in two rows on a slender flattened or triangular rachis. Spikelets 2·0 to 2·8 mm. long, 0·8 to 1·0 mm. broad. Glumes II and III membranous, pale green with darker veins, hairy, conspicuously pointed, and extending beyond the fruit. Glume II often reddish coloured. Glume IV and palea chitinous. Stamens three, anthers yellow (when full of pollen) with narrow purple outer edges. Stigmas white.

Axonopus affinis Chase. Usually more free flowering than *A. compressus*. Flowering culms slender, compressed. Nodes more or less glabrous. Leaf-blades 4 to 8 mm. wide, 6 to 30 cm. long, uppermost blade on culm very short, 2 to 6 cm. long. From cone on upper node of culm 3 to 6 very slender peduncles (1 to 3 conspicuous), 15 to 30 cm. long. Each peduncle bears 2 or 3, occasionally 4 to 6, slender racemes, the first two racemes at the apex of peduncle, one terminal, the second subterminal, the others, when present, alternating at short intervals below. Racemes 3 to 10 cm. long.

Spikelets usually hairy, not very closely spaced, alternating in two rows along a slender flattened or triangular rachis, 1·8 to 2·2 mm. long, 0·8 to 1·0 mm. broad (they are much less pointed than those of *A. compressus*). Glumes II and III membraneous, pale green with dark veins hairy, hardly extending or extending to a short point beyond the fruit, mid vein very indistinct. Glume II often reddish coloured. Glume IV and palea chitinous. Stamens three, anthers purple with translucent dots. Stigmas mauve.

Both species produce seed freely.

Utility

A. affinis withstands dry weather better than *A. compressus* and is capable of covering the soil better in dry exposed situations. On poor, unshaded soil, in this country, the former species frequently grows by densely-leafy, short internoded stolons, and it is probable that it will, in time, largely predominate in such conditions.

Under medium shade, however, where both make their best growth, *A. compressus* appears to have a distinct advantage.

There is some slight confusion as to palatability and value of carpet grass as pasture, but this is partly due to the previous confusion of two species with but one name.

There is no doubt that the true *Axonopus compressus* Beauv. is a good pasture grass, being recognised as such in tropical America and Australia. It appears equally true that *A. affinis* has a variable reputation. It is definitely regarded as inferior in Australia, and chemical analyses quoted by McLennan clearly show it to be inferior, as fodder, to *A. compressus*.

In Malaya a few years ago *A. affinis* appeared to be liable to cause purging of cattle, due to a slight increase in hydrocyanic acid content if cut at too short intervals. The author has, however, seen *A. affinis*, under light shade, grazed by cattle with relish, and obviously in preference to *Paspalum conjugatum*.

Summary

A detailed account is given of the two species *Axonopus compressus* Beauv., and *Axonopus affinis* Chase, and the differences between them.

The chief distinguishing features may be summarised as follows:—

	A. compressus Beauv. Savannah Grass.	*A. affinis* Chase. Carpet Grass.
Leaves.	Broad, hairy frequently with red colouration.	Narrower, stiff, folded, more or less glabrous.
Nodes.	Very hairy.	Hardly hairy.
Spikelets.	Long and pointed.	Blunt or short pointed.
Anthers.	Yellow with narrow purple outer edges.	Purple, with translucent dots.
Stigmas.	White.	Mauve.

The writer wishes to acknowledge with thanks much careful work by his Laboratory Assistant, Che Mohd. Kassim, in the preparation of the illustrations.

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PERIODIC LEAF-CHANGE AND FLOWERING OF TREES IN SINGAPORE (II)*

By R. E. HOLTTUM

In my earlier paper on this subject, I published observations made on a number of trees during the years 1927–1931, and summarized previous observations published elsewhere on the behaviour of trees in the eastern tropics. I also gave a short account of the climate of Singapore. The main item of new information arising from my own observations was that a number of deciduous trees had fairly constant leaf-periods, which had no relation to the yearly calendar; and the conclusion drawn from this was that the length of leaf-period in such trees is due primarily to senescence of leaves, the climate of Singapore being so uniform as to have little or no control.

Subsequent observations, in some cases over a total period of ten years or more, have confirmed the fact that many deciduous trees have fairly constant leaf-periods not related to climate; but they have also shown many curious irregularities which are not always easy to explain. It is clear that there is every variety of response from almost complete independence of climatic change to extreme susceptibility, and a tree that is regular in behaviour for a time may later show an unexpected change (*e.g.* Koompassia).

My earlier generalizations therefore need modification in some measure, and a fuller discussion of the whole subject is given below, followed by details of behaviour of individual trees.

Climate

The temperature of Singapore is so uniform throughout the year as to have little significance in the present connection. The only phenomena of temperature-change which influence plant behaviour are sudden falls of 10 to 15 degrees (Fahrenheit) during storms, and possibly also cool days following hot weather. These stimulate certain plants to flower; chiefly orchids, but also some woody plants, notably *Pterocarpus indicus*.

The average rainfall of Singapore is nearly 100 inches (2540 mm.), uniformly distributed, the driest calendar month having a mean of about 6 inches (152 mm). The only constant periodic change in the climate is the wetter season from October to January, when in addition to the greater rainfall there is frequent heavy clouding and light rain, resulting in continuously moist conditions over considerable periods, in contrast to the relatively short

* For the first paper on this subject, *see* Gard. Bull. S.S. 5: 174–206. 1931.

periods of heavy rain characteristic of most of the rest of the year. There is often a sudden break at the end of the wet season, in January or February, and this is usually the most pronounced climatic change in the year. It varies in its intensity.

Though the driest month has a mean rainfall of about six inches, there are drier months than this in almost every year. A list of the calendar months with less than 2·5 inches of rain (63 mm.) since 1890 shows the following frequency of occurrence:

February	7	times
March	3	„
April	1	„
July	6	„
August	3	„
September	2	„

Thus there is an indication that exceptionally dry weather tends to occur either about February–March or July–August, but it will be noted that in 49 years there were only 22 calendar months with less than 2·5 inches of rain, and (as shown by the figures at the end of this paper) there is very great variation in the distribution of rainfall from year to year. In the period 1927–1937, the following were the longest periods without rain:—

24. 1.35–14. 2.35	22	days
21. 7.35– 9. 8.35	20	„
3. 2.33–19. 2.33	17	„
8.12.34–23.12.34	16	„
13. 7.28–27. 7.28	15	„
26. 7.29– 9. 8.29	15	„
24. 7.37– 6. 8.37	14	„

The extremes of dry weather are thus relatively slight as compared with most tropical climates, and are never such as to necessitate leaf-fall of trees; and though extreme dry weather may usually occur about February and July, it is not frequent enough to ensure uniform behaviour of all trees, and lesser dry periods may occur at almost any time. Dry periods of from 7 to 13 days occurred as follows in 1927–1937:

in January	2	periods
February	4	„
March	5	„
April	1	„
May	5	„
June	3	„
July	9	„
August	2	„
September	4	„
October	2	„
November	–	„
December	1	„

A period of seven days without rain, following a period of wet weather, is probably enough to stimulate certain

trees to flower; but response varies according to the condition of the tree, and is in fact so complex that it is difficult to analyse. Reference to *Fagraea fragrans* and *Saraca taipingensis* will give some indications on this point. Most trees (other than those that flower continuously) probably need more than seven days drought as a stimulus to flowering.

Atmospheric humidity is high every night, rising above 90% soon after sunset; in the daytime it may fall to about 60% in dry weather, but in the wet season often only to 85%.

An appendix to this paper gives the daily rainfall, in inches, at the Botanic Gardens, Singapore, from 1927 to 1939.

Deciduous trees with annual leaf-renewal

Trees of the following species have been strictly annual in their leaf-renewal:

Kigelia pinnata (mean date 28 January)
Hymenaea courbaril (early February)
Parkia javanica (mean date 23 February)
Terminalia subspathulata (mean date 6 April)
Canarium rufum (mean date 9 May)
Lecythis sp. (mean date 11 August)

The coefficients of variation of these trees vary from 2·0% to 7·5%, and presumably indicate corresponding differences in susceptibility to climatic variation.

The mean dates of leaf-renewal are interesting. It is probably significant that the two trees with the lowest variation (Parkia and Kigelia) renew their leaves in January–February, following the most regular seasonal change in the climate, whereas those with mean date of leaf-renewal in April and May (Terminalia and Canarium), when there is much variation of climate conditions, show the greatest variation. Lecythis, changing about August, is intermediate. Hymenaea is not quite deciduous, and no exact dates are recorded, but the tree concerned seems to be quite regular in its behaviour.

There are other trees that appear to have a tendency to a period of slightly less or slightly more than 12 months. Such trees as these may keep to very near 12 months for some years, if they change their leaves at a time when dry weather is most likely to occur; but sooner or later they have a short or a prolonged leaf-period, and this may be the prelude to a series of irregular periods until the change occurs once more at a time when climatic change is most regular. For an example of shortening periods see *Cassia nodosa;* for lengthening periods *Koompassia malaccensis.* The latter had been observed over three periods when I

wrote my earlier paper; it then appeared to have a period of exactly a year, with leaf change in September. It subsequently deferred its change until November and then had several periods of considerably more than 12 months.

Two young trees of *Kigelia pinnata* have indicated that the date of leaf-renewal may be dependent on the date of planting, and also that root-stimulus by manuring and cultivation may induce new growth and result in a change of some months in the date of leaf-renewal. The relation of the first leaf-change to the date of planting of a young tree is one that varies considerably from species to species, and observations on this point would be of considerable interest.

Deciduous trees with leaf-period of more than a year

Several deciduous trees have been observed to show a mean leaf period significantly more than 12 months. These are as follows:

Species	*Period (months)*	*s.d.*		*No. of periods*
Cedrela Glaziovii A ..	12·5	·70 or	5·6%	11
Koompassia malaccensis	12·7	1·36	10·7%	12
Hevea braziliensis ..	13·3	·86	6·5%	9
Cedrela Glaziovii B ..	14·0	1·7	12·1%	10
Caesalpinia ferrea ..	14·2	1·2	8·5%	5
Homalium grandiflorum	13·7	1·9	13·9%	7
Anisoptera megistocarpa	13·8?	1·65?	12·0%	10?
Parishia Maingayi ..	15·6	·96	6·2%	6
Heritiera elata ..	20·5	2·6	12·7%	4
Heritiera macrophylla ..	32	1·3	4·1%	4

The two trees of *Cedrela Glaziovii* provide a remarkable contrast, as they are growing near together and under apparently identical conditions. It is remarkable that the tree showing a period of only 12·5 months, which one might perhaps think not significantly different from 12·0 months, has had a very small coefficient of variation over a period of eleven years. The other tree, which evidently has a tendency to decidedly longer periods, is probably also more influenced by climatic change. Climatic influence is more clearly seen in the Koompassia, which has had its longest leaf-periods when change was due in the wet season. Such a tree may show almost exactly 12-month periods for several years, then a series of longer periods with change later and later in the wet season, then a series of nearly 12–month periods again. The Koompassia tree in question would probably be a strictly 12–month tree in a climate with a pronounced annual dry season. (Another Koompassia tree seems to be more irregular).

The Hevea with a very regular period of over 13 months is also interesting, because most Hevea trees in

Singapore are very irregular in their behaviour, changing some or all leaves at any period of dry weather (according to their previous history and the intensity of the drought). Schweizer's observations in a much more seasonal climate in Java indicate also variation in behaviour of different trees of Hevea; for further notes on this question, see below under the heading *Deciduous Trees with no regular leaf-periods.*

The behaviour of the Anisoptera tree has been decidedly irregular, and it is not at all obvious how climatic influence can have caused the observed variations. The Homalium tree also had one exceptionally long period which seems unaccountable on climatic grounds.

The two species of Heritiera are the most remarkable cases in this group, one being native to Malaya and the other from Burma. It would be very interesting to have some information about the behaviour of *H. macrophylla* in its seasonal native climate. Such a leaf period as 2½ years in a deciduous tree must surely be very exceptional, though individual leaves of lesser evergreen trees and shrubs in the shade of rain-forest may not infrequently last as long as this.

Trees with leaf-periods between 6 and 12 months

A number of trees have shown regular periods of less than a year; these are as follows, with the exception of those having a six-month period, which are considered separately below.

Species	*Period (months)*	*s.d.*		*No. of periods*
Adenanthera pavonina ..	7·25	·74	or 10·2%	16
Cassia fistula A	9·1	·93	10·2%	15
Cassia fistula B	10·5	1·26	12·0%	8
Cassia fistula C	9·6	·84	8·7%	14
Cassia nodosa (1928–35)	11·7	·4	3·4%	7
Cratoxylon formosum A	9·1	1·09	12·0%	15
Cratoxylon formosum B	9·1	·74	8·1%	15
Delonix regia ..	8·8	·94	10·7%	11
Ficus variegata A	6·5	·84	12·9%	20
Ficus variegata B	6·4	·85	13·3%	19
Ficus variegata C	6·1	·65	10·7%	9
Ficus variegata D	6·1	·62	10·1%	13
Lagerstroemia flos-reginae, north side ..	9·2	·88	9·6%	13
Lagerstroemia flos-reginae, south side ..	8·9	·77	8·7%	13
Lagerstroemia flos-reginae old tree ..	9·4	·99	10·5%	13
Salmalia malabarica A	10·5	·44	4·2%	13
Salmalia malabarica B	9·3	·98	10·5%	12
Sterculia macrophylla Pg.	6·9	—	—	4
Sterculia macrophylla S.	7·0	—	—	4
Sterculia sp. ..	10·1	1·26	12·5%	15

It will be noted that nearly all of these trees have a coefficient of variation of about 10%. It is notable that one of the two exceptions, namely the tree of *Cassia nodosa* with a coefficient of only 3·4% in the period 1928–35, showed subsequently a very irregular behaviour. This is discussed further under the heading of irregular trees.

Apart from the indication that a considerable number of deciduous trees have regular periods independent of the climatic cycle, the most interesting feature of the above table is the comparison of different trees of the same species.

In the case of *Salmalia malabarica* the tree with the more regular period is the more vigorous. This species is interesting as being the only one that has a considerable obligatory resting period; such trees are often intolerant of the Singapore climate. The standard deviations of the three trees of *Cassia fistula* are also in the order of their vigour, the most vigorous showing the least deviation. This may be partly connected with the fact that in this species no exact date for leaf-renewal can be given, the process being slow and not always uniform all over the tree; the observer is therefore liable to greater variation in recording dates for the less vigorous trees. There is an indication that some trees of this species in Singapore have a period of 12 months.

The two trees *Cratoxylon formosum* are in different localities, and have never changed simultaneously, but both have a period of 9·1 months. One tree has a substantially greater variation than the other, though both are equally vigorous and of about the same size. It is to be noted that this species appears to have a period of 12 months in the more seasonal climate of Penang.

The four trees of *Ficus variegata* are of considerable interest, as they come very near the six-month trees. It is clear however that trees A & B, which have been longest under observation, have a period significantly longer than six months, and also a rather high standard deviation, whereas the three six-month trees appear to have a low standard deviation. As pointed out below, however, observation must be carried out over a longer period of years if a true picture of their behaviour is to be obtained.

The two trees of Lagerstroemia, like those of Cratoxylon, are situated some distance apart, have almost equal periods, and do not change simultaneously. The tree of which the two halves have different periods is considerably younger than the other.

The *Sterculia macrophylla* at Penang is interesting as showing a period of seven months in the much more seasonal Penang climate. A second Singapore tree seems

to have a considerably longer period; but it has not been observed long enough since its treatment of cultivation and manuring to allow of a definite statement being made.

Six-month trees

A few species of trees have a regular period of six months. There are indications that in some cases trees of Peltophorum have longer periods than this, but in the cases observed the trees were either young or in poor condition or affected with insect pests. The list of trees observed in the six-month class is as follows:—

	s.d.	*c.v.*	*Mean dates*		*No. of periods*
Couroupita guianensis ..	·43	7·2%	15 Mar.	20 Sept.	16
Peltophorum pterocarpum ..	·43	7·2%	12 Feb.	10 Aug.	22
Terminalia catappa ..	·64	10·5%	8 Feb.	11 Aug.	22

It is remarkable that the exotic Couroupita has been more regular than the local Terminalia in its behaviour. The dates February–March and August–September for leaf-change follow closely the periods of incidence of the driest weather and are probably controlled by these periods.

Deciduous trees with no regular leaf-periods

There is probably no very sharp distinction between this class and that of the regular trees, the gap being bridged by those which have high standard deviation. The irregular trees here considered are in fact those which are most affected by small climatic changes, which in Singapore are of irregular occurrence. The most remarkable of the irregular trees under observation are *Cassia nodosa, Dyera costulata, Ficus caulocarpa, Hevea braziliensis, Mangifera indica, Sindora Wallichii,* and *Sterculia carthagenensis.* Each of these presents some peculiar features, which are discussed under the appropriate headings below. The most striking may be mentioned here. *Cassia nodosa* showed a very regular period of 11·7 months for several years, and then behaved very irregularly. *Ficus caulocarpa* is the most irregular of all, and I cannot trace any connection between its behaviour and climatic change. Hevea trees mostly lose some leaves, and sometimes all, when there is dry weather, but the single tree with a regular period of 13·3 months is a notable exception. *Sterculia carthaginensis* is a very interesting case, discussed below in some detail.

It has been clearly shown by Schweizer's experiments that Hevea leaves have a minimum life of about 5 months; and it is probable that most other irregular trees have similarly a minimum period for which the leaves must be retained, the leaves being liable to fall in any dry weather after they have attained this minimum. There is probably always considerable variation from tree to tree in this class, according to the individual nature of the trees, their position (soil, exposure etc.) and previous history.

Flowering of Deciduous and Evergreen Trees

The flowering of deciduous trees always takes place at a definite point in the leaf-cycle; on the old wood before new leaf growth (*Erythrina indica*), simultaneously with the growth of new leaf shoots (*Cratoxylon formosum, Cassia fistula*), or at the end of the new leafy shoots (Lagerstroemia, Peltophorum). Flowering may be much or little, or even often absent in some cases (Homalium, *Terminalia subspathulata*). The extent of flowering depends no doubt on the climatic conditions at the time the flower buds are formed. It is notable that Delonix trees flowering in Singapore at some seasons are much fuller of flowers than those flowering at other seasons. In some species, on the other hand, flowering is very much the same whatever the season (*e.g.* Lagerstroemia) and there is probably in all cases some difference in response according to innate differences from tree to tree. But whatever these differences in response, flowering always occurs at a definite point in the leaf-cycle, and cannot occur at any other time. From this it follows that, with trees having a leaf-period of less than 12 months, there is no definite flowering season, and little response to climatic change, but a sporadic flowering of individual trees throughout the year.

The flowering of evergreen trees, on the other hand, is usually not dependent on the leaf-cycle, and bears no relation to new leaf growth. Flowering is dependent on dry weather, but the intensity of drought needed to produce flowering, and the time which elapses between the onset of dry weather and the opening of flowers, vary greatly from species to species. Examples are given under *Saraca taipingensis* and *Fagraea fragrans*. Some evergreen trees however flower at the end of new leaf-growth (*e.g. Eugenia grandis, Cinnamomum iners*).

Evergreen trees produce new leaf-growth at intervals of a few months (sometimes as much as a year or more), the intervals apparently much less regular than the leaf-periods of most deciduous trees. The old leaves usually do not fall as soon as the new have grown, but remain

on the tree for some time afterwards, their total life-period being often very long. There are however cases rather intermediate between the normal deciduous and evergreen types, such as *Dyera costulata* and *Eugenia grandis* (*see* my 1931 paper, p. 191). Probably in most cases new leaf growth of evergreen trees is dependent on some climatic stimulus, often rainy weather; but little information on this point is available. Some data will be found below under *Mangifera foetida* and *Saraca taipingensis.*

Statistical significance of the records

In all cases the mean leaf-period has been calculated, and where the number of observations is sufficient, the standard deviation, which is the usual measure of variability. This is calculated by taking the difference of each leaf-period from the mean, squaring these differences, dividing their sum by $n-1$ (n being the number of periods) and taking the square root of the result. If one date of a series has been missed, the double period is divided, and two equal periods entered for calculation of differences from the mean, but the sum of the squares is divided by $n-2$ instead of $n-1$.

As noted above, it appears that standard deviation, when expressed as a percentage of the mean period, gives a measure of the susceptibility of a tree to climatic influences. It is notable that in two instances (*Cassia fistula* and *Salmalia malabarica*) a more vigorous tree has a smaller deviation than a less vigorous tree of the same species, indicating that a more vigorous tree is less susceptible to climatic influence. It may be that the more vigorous tree, having a larger and more widely spreading root-system, has access to a larger amount of soil moisture, and is correspondingly less affected by a period of dry weather.

I am grateful to Dr. E. J. Maskell for advice concerning the data presented in this paper, and for making a statistical comparison of some of them, to assess their significance. The results of this treatment of a few of the records, summarized in the following paragraphs, will give a general idea of the significance of the records as a whole.

Taking two trees which have leaf-periods of more than a year, namely *Hevea braziliensis* and *Sterculia macrophylla*, calculation indicates that the probability in either case that the figures presented show chance behaviour of trees whose true period is 12 months, is less than ·01. That is, the probability that these trees have a natural period of more than 12 months is very high.

Taking pairs of trees of the same species which have shown different mean periods, the following results were found. In the case of *Salmalia malabarica,* the probability that the differences observed between the two trees are a chance result is less than ·02; this indicates that the differences observed are fully significant. In the case of the two trees of *Cedrela Glaziovii,* the probability is greater than ·02, but less than ·05; this also indicates a significant difference. In the case of *Ficus variegata,* however, comparing trees A and B, A and C, the differences are found not to be significant. In these trees, the mean periods are near together, and the deviations rather high, so that a longer period of observation is needed to indicate significant differences between them.

It should be noted however that though the differences between a pair of trees such as the two Salmalias may be significant, this does not necessarily indicate that the whole difference is due to the individual natures of the trees. A tree with good soil and other favourable environmental factors may be more vigorous than a tree less favoured, and the two might on that account show some difference of leaf-period. On this point, we have no evidence. All we can say is that in an identical climate two trees of the same species may show a significant difference of behaviour, part of this being presumably due to innate differences between the two trees and part to differences of soil conditions and other topographical factors. In the case of the two Cedrela trees, the differences of soil and topography appear to be negligible, but one cannot be entirely sure of this. An appropriate experiment would be to propagate the two trees vegetatively, and observe whether the offspring, planted together in a different place, continued to show the differences of their parents.

Conclusion

The observations presented in this paper indicate clearly that the climate of Singapore is so uniform on the whole that many trees change their leaves at intervals which have no relation, or little relation, to climatic change. It is clear however that there is much variation in regularity of behaviour among such trees, even between different individuals of the same species. One can find all conditions from trees with very high constancy of period (the period bearing no relation to the calendar year) to trees that are so susceptible that they may renew at least some of their leaves at any small climatic change.

The constant-period trees appear to be organized on the principle that their leaves are efficient for a certain

period, and are then shed and renewed, whatever the season. For these trees, no climatic change experienced in Singapore is sufficient to make them change their leaves much earlier or later than their proper period, which is dependent on the nature of each tree, and perhaps also on its soil conditions or other local factors. However, trees of these same species in climates with long dry seasons may change their leaves at intervals of exactly a year. It is the climatic uniformity of Singapore which permits such trees to show their individuality; in the interplay of internal and external factors, the internal are here by far the stronger.

At the other extreme are trees which are considerably affected by such climatic changes as do occur in Singapore. As such changes are very irregular over a great part of the year, trees of this kind are irregular in behaviour. They appear to be organized on the principle that their leaves have a *minimum* life; any dry period occurring after the minimum may cause some leaves to fall, with subsequent leaf-renewal. There is no sharp distinction between these trees and those which have constant leaf-periods; the gap is bridged by trees showing varying degrees of deviation from regular periods.

Another point to observe, deserving of future attention, is that interference with the roots of trees may completely change the rhythm of their leafy shoots. It seems likely that stimulation of roots at a sufficient interval after the last new leaf-growth will stimulate new leaf-growth, followed by fall of the old leaves; but that the reaction will depend on the age of the last leaf-growth, much in the same way that Hevea leaves have a minimum life. But different trees will doubtless behave in different ways, and much of interest may emerge from watching their reactions.

Evergreen trees differ from deciduous trees in not losing their old leaves when new ones are produced; the growth of new leaves is not a consequence of the loss of the old, and must be due to some other stimulus. Observations on the behaviour of evergreen trees are few (*see Mangifera foetida,* in this paper), but I think they also will be found to vary in their response to climatic stimulus. It is clear that some (*e.g.* Saraca) are stimulated by wet weather to produce new leaves, and that such production comes at irregular intervals. The length of such intervals and their dependence or otherwise on climatic stimulus probably vary as much from species to species as in the case of deciduous trees. A further important point of difference between evergreen and deciduous trees is that in the former flowering is usually independent of vegetative growth, whereas in the latter flowering always comes at a definite point in the leaf-cycle.

Records of Individual Trees*

Adenanthera pavonina L.

The tree reported on in 1931 has been under continuous observation since that time, and has maintained an average leaf-period of 7·25 months, with a standard deviation of ·74 month over 16 periods. The longest period was 8·4 months and the shortest 6·2; both these occurred in the records formerly reported. Leaf-renewal has occurred in every month of the year except February, June and November.

Leaf-renewal after the 8·4 month period occurred towards the end of a 2-month drought; if this prolonged dry weather was the cause of deferring leaf-renewal, it is difficult to see why leaf-renewal after the short period of 6·2 months took place at the end of one month's dry weather. In both cases the new leaves developed before any considerable rainfall had broken the drought. A subsequent record of leaf-renewal on 9th July, 1938 gives an average of about 7·5 months for two leaf-periods after 11th April, 1937.

It should be noted that this species is said to be annual in its behaviour at Peradeniya, losing its leaves towards the end of the year. On a recent visit which I paid to Colombo in October, I noticed that all trees were in old leaf with ripe fruits, and the same appeared to be the case at Bombay a few days later. See however remarks under *Peltophorum ferrugineum.*

The following table gives dates of leaf-renewal, with the length of each leaf-period, and also the standard deviation as calculated from these figures.

	Months		*Months*
27. 8.27	—	15. 1.33	8·2
22. 3.28	6·8	6. 9.33	7·7
21.10.28	7·0	April 1934	7·+
28. 4.29	6·2	1.12.34	7·+
8.12.29	7·3	15. 7.35	7·5
21. 8.30	8·4	1. 3.36	8·5
10. 3.31	6·6	10.10.36	7·3
4.10.31	6·8	11. 4.37	6·0
8. 5.32	7·1		

16 Periods.
Mean period: 7·25 months.
Extremes: 8·4 and 6·2 months.
Standard deviation: ·74 month or 10·2%.

Anisoptera megistocarpa van Sl.

A large tree of this species in the Gardens Jungle has been under observation since 1928; it has shown considerable variation in behaviour, with long leaf-periods

* In the records which follow, dates of leaf-renewal are the dates on which leaf-buds were seen to be starting new growth.

throughout. The tree is slowly deciduous during many weeks, new growth appearing when it is almost bare of leaves. It has had six periods varying between 12 and 16·5 months, and two much longer periods of 23·8 and 28·2 months. The crown of the tree is clearly visible from my house, though distant, and I am confident that these two long periods represent intervals between new growth following bare phases. It is possible however that (as with the tree of Dyera) new growth may have occurred without a preceding leaf-fall during these long periods; I might have missed such new growth, as there is little colour change between new and old foliage. If we assume that the long periods are in fact double periods (so far as new growth is concerned), we find that the standard deviation is 12%, which is no greater than in a number of other trees; taking them as single periods, the standard deviation is very high.

In any event, more observation is needed to understand the behaviour of this tree. One cannot see any relation between the dates of leaf-renewal and rainfall. Leaf-renewal in March, 1931, March, 1932 and April, 1933 took place after rather dry weather in February (average 115 mm.) which was absent in 1935; but if a dry February causes leaf-renewal, it is curious that the much drier month of February, 1936 (43 mm.) had not a more immediate effect. The dates of new leaf-growth, and the intervals in months between them, were as follows.

	Months		*Months*
18. 8.28	—	2. 6.34	14·0
8.12.29	15·7	27. 5.36	23·8
12. 3.31	15·1	15.10.37	16·5
13. 3.32	12·0	22. 2.40	28·2
1. 4.33	12·6		

Reckoning the periods 23·8 and 28·2 as double periods (*i.e.* as 2 × 11·9 and 2 × 14·1 months respectively), we have the following:—

10 periods; mean period 13·8 months,
extremes 12·0 and 16·5 months.
Standard deviation: 1·65 months or 12·0%.

Caesalpinia ferrea Mart.

A single tree of this south American species, apparently the only mature tree of its kind in Singapore, grows in the Botanic Gardens. It has made vigorous growth, and is very handsome, but flowers poorly and sets very few fruits. The tree is deciduous, its leaf-fall taking place slowly over a period of several months. Before all the leaves are gone, new growth appears on isolated twigs (as in *Cassia nodosa*), but general new leaf growth, which is very rapid when it does occur, is deferred until practically all old

leaves are gone. The dates given are for the occurrence of general new leaf growth, and are therefore less precise than those given for some other trees.

An isolated observation of this tree was made in 1929; continuous records date from 1934. The gap in observations is exactly four times the mean period for 1934–1940. For the years 1934–1940, the standard deviation is below 10%, so it is fairly clear that this is a tree with a period of more than 12 months. A few seedlings have now been obtained from it, and their development will be watched with interest. The following are the observed dates of general leaf-renewal.

		Months			*Months*
25.8.29	..	—	26.9.37	..	14·5
23.5.34	..	4 × 14·2	1.1.39	..	15·2
19.6.35	..	12·9	22.4.40	..	15·7
12.7.36	..	12·8			

For the years 1934–1940 (5 periods) we have:—
Mean period: 14·2 months.
Standard deviation: 1·2 months or 8·5%.

Canarium rufum Benn.

This local tree has been under observation only since 1935. It appears to have a 12–month period. It is on the edge of the Gardens jungle, growing under good conditions. Leaf-fall is rather sudden, and leaf-renewal takes place as soon as the tree is bare. New leaf buds have opened on the following dates.

	Months	
1.5.35	—	Mean leaf-period: 12·0 months.
20.5.36	12·6	Standard deviation: ·65 month
4.6.37	12·5	or 5·4%.
20.4.39	2 × 11·3	Mean date: 9 May.
30.4.40	12·3	

Cassia fistula L.

The two trees mentioned in 1931 have been under observation since that time, and also a third tree. The two former trees have latterly both shown signs of lack of vigour, but the third tree is very vigorous and has flowered heavily on all occasions. As noted previously, it is not easy to fix an exact date for leaf-renewal of trees of this species; the dates are therefore subject to a greater margin of error than most of the other observations recorded in this paper. The tree B showed such a slow change that no observations on it were made after 1935. A fourth tree lately brought under observation near the others has had one period of 10·6 months.

Two exceptionally large and vigorous trees at Government House, Singapore, have renewed their leaves and flowered in May or June in the following years: 1928, 1931,

1938, 1939. It seems likely that these trees have a period very nearly of 12 months. It is evident therefore that observations on further trees are desirable.

The dates of leaf-renewal of the three trees for which the longest observations are available, with other data, are as follows:

A		*B*		*C*	
	Months		*Months*		*Months*
11.12.27 ..	—	8. 3.28 ..	—	11.12.27 ..	—
11. 9.28 ..	9·0	13. 1.29 ..	10·2	28.10.28 ..	10·6
1. 6.29 ..	8·7	24.11.29 ..	10·4	22. 2.31 3 ×	9·3
1. 3.30 ..	9·0	10. 9.30 ..	9·6	13.12.31 ..	9·7
1.12.30 ..	9·0	25. 5.31 ..	8·5	27. 8.32 ..	8·4
29. 8.31 ..	8·9	8. 5.32 ..	11·5	28. 6.33 ..	10·0
8. 5.32 ..	8·3	16. 5.33 ..	12·3	Mar. 1935 2 ×	10·5
1. 3.33 ..	9·8	10. 3.35 2 ×	10·9	10. 1.36 ..	10·
29. 3.35 3 ×	8·3	Mean period: 10·5 months.		4.10.36 ..	8·8
26. 2.36 ..	10·9 early	Standard deviation: 1·26 months or 12·0%.		28. 6.37 ..	8·7
Jan. 1937 ..	10·5			May 1938 ..	10·
Oct. 1937 ..	9·5			26. 2.39 ..	9·
5. 4.39 2 ×	9·0			Mean period: 9·6 months.	
Mean period: 9·1 months.				Extremes: 8·4 and 10·6 months.	
Extremes: 8·3 and 10·9 months.				Standard deviation: ·84 month or 8·7%.	
Standard deviation: ·93 month or 10·2%.					

Cassia nodosa Buch.-Ham.

The tree mentioned in 1931 continued its leaf-renewals after slow and prolonged leaf-fall in the early part of the year, tending to become earlier each year up to 1935, for which the date recorded is 10 March. The dates given are for general new growth of leaf buds, and are usually about a month later than the first new buds which develop here and there on small branches in advance of the remainder of the tree. The standard deviation for this period is remarkably low.

Then in December, 1935, possibly as a result of the rather dry period from July to October, about ¾ of the branches on the tree produced new leaves. The remaining branches did not bear new leaves until March, 1936. The branches which had new growth in December, 1935 renewed their leaves again in July, 1936. In April, 1937 all branches renewed their leaves.

This tree is said to have been produced from a seed from Pahang, where the species is common, and leaf-renewal with flowering is general about May. It appears likely that the more uniform climate of Singapore has allowed our tree to show a tendency to instability or to sensitiveness to climatic changes. A number of young trees of this species have lately been planted, and their behaviour will

be watched with interest. Data for the period 1928–1935 are given below.

	Months
28.5.28	—
15.5.29	12·1
15.4.30	11·0
12.4.31	11·9
16.4.32	12·1
9.4.33	11·8
20.3.34	11·4
10.3.35	11·7

Mean period: 11·7 months.
Extremes: 11·0 and 12·1 months.
Standard deviation: ·4 month or 3·4%.

Cedrela Glaziovii C. DC.

The trees of this species were wrongly ascribed to *C. toona* in my 1931 paper. These two trees have been under observation since that time and have shown a remarkable difference in behaviour. Both are tall vigorous trees growing near together under good soil conditions. They behave alike in their slow leaf-fall, from the top downwards, and the appearance of new leaves first on the top branches after the whole tree is bare. One tree has had a mean leaf-period of 12·5 months, advancing its time of leaf-fall from July to December during the period under review, with a very small standard deviation. For the first few years it appeared likely that this tree had a period of exactly 12 months, but it now seems more likely that there is a significant departure from this figure.

The other tree has shown less regularity (though its coefficient of variation is only 12%), and has throughout had leaf-periods decidedly more than 12 months, with a mean of 14·0. Most of the periods have been 13 to 14 months, but one was 17·7. This long period included the whole of 1932, the driest year in the period 1927–38. For other cases of difference of behaviour between trees of the same species, see *Ficus variegata,* Hevea and Peltophorum.

The following table shows how one tree had ten leaf-periods and the other only nine, in the same period of years.

	Months		*Months*
8. 7.28	—	Aug. 1928	—
4. 8.29	12·9	Sept. 1929	13·
30. 7.30	11·9	end Sept. 1930	12·5
1. 8.31	12·0	13.12.31	14·7
9. 8.32	12·3	4. 6.33	17·7
13. 8.33	12·1	July 1934	13·
10. 8.34	11·9	12. 8.35	13·
10. 8.35	12·0	Oct. 1936	14·
12. 9.36	13·1	end Oct. 1937	12·5
12. 9.37	12·0	2.12.38	13·1
17.10.38	13·2	19. 4.40	16·6
15.12.39	14·0		

11 periods: mean period 12·5 months.
Extremes: 11·9 and 14·0 months.
Standard deviation: ·70 month or 5·6%.

10 periods: mean period 14·0 months.
Extremes: 12·5 and 17·7 months.
Standard deviation: 1·7 months or 12·1%.

Ceiba pentandra (L.) var. **caribaea** (DC) Bakh.

A tree of this variety (the West Indian Kapok), received as a stump from Buitenzorg and planted in October 1933, has shown a six-month leaf-period since 1936. The new leaves appear before the old have quite fallen; the change was very gradual in September, 1938 and March, 1939. Observed dates (incomplete) of new leaf production were:

8. 4.36	Sept. 1938
27.10.36	March 1939
25. 4.37	March 1940
15.10.37	Sept. 1940

Another tree of the same origin, planted at another place but at the same time, renewed its leaves on 28th December, 1936, 1st June, 1937, 9th February, 1939 and 26th July, 1939. It has thus shown a similar six-month period, but has changed its leaves at different times from the first tree. The reason is probably that this tree was cultivated and manured some time after planting (the first tree has never had such treatment), but the date of this treatment was not recorded. For a similar case, *see* Kigelia.

A seedling raised from seed from the Gold Coast has also shown a six-month period. *Ceiba pentandra* in Java has a twelve-month period. Possibly these young trees will lengthen their period as they grow older.

Couroupita guianensis Aubl.

An old tree of this species was reported as having three six-month periods in 1929-1931. A record over 16 periods is here presented, the average being still exactly six months and the standard deviation identical with that of the tree of the local species *Peltophorum pterocarpum*. Leaf-fall is very rapid, and also leaf-renewal; the dates given are therefore closely comparable. The tree is only bare for a day or two.

A young tree, planted in 1925 in a thicket among other trees which restricted its growth, did not behave at all regularly at first, but it appears to be settling down to a more regular rhythm as it grows older; it now has its crown clear of other trees and is growing more vigorously, but has not yet begun to flower. It does not change its leaves at the same time as the old tree.

In *De Tropische Natuur*, XXIII (1934), p. 244, it is recorded that the Couroupita trees at Buitenzorg change their leaves in March–April and September–October, thus

agreeing with the old Singapore tree. Mr. Ahmadi, Superintendent, Municipal Gardens, Bombay, informs me that the Couroupita trees in the Victoria Gardens, Bombay, change their leaves regularly in March and October. This regularity of behaviour in such different climates is remarkable.

The observed dates of leaf-renewal of the young tree in Singapore were as follows:

	Months		*Months*
19. 4.32 ..	.. —	9. 7.36 ..	.. 7·9
7. 1.35 ..	.. 8·5	25. 1.37 ..	.. 6·5
27. 1.34 ..	.. 12·7	20. 7.37 ..	.. 5·9
23. 5.35 ..	2 × 7·9 ?	15. 8.39 ..	4 × 6·2 ?
13.11.35 ..	.. 5·7	22. 2.40 ..	.. 6·2
		18. 8.40 ..	.. 5·9

The data for the old Singapore tree are as follows.

	Months		*Months*
15. 9.29 ..	.. —	8. 9.33 ..	.. 5·6
23. 3.30 ..	.. 6·3	19. 3.34 ..	.. 6·4
16. 9.30 ..	.. 5·8	7. 9.34 ..	.. 5·6
22. 3.32 ..	.. 6·1	12. 3.35 ..	.. 6·2
18. 9.31 ..	.. 5·9	15. 9.35 ..	.. 6·1
5. 3.32 ..	.. 5·6	25. 3.36 ..	.. 6·3
10. 9.32 ..	.. 6·2	5.10.36 ..	.. 6·4
19. 3.33 ..	.. 6·3	17. 4.37 ..	.. 6·4
		12. 9.37 ..	.. 4·8

16 periods.
Mean period: 6·0 months.
Extremes: 4·8 and 6·4 months.
Standard deviation: ·43 month or 7·2%.
Mean dates: 15 March and 20 September.

Cratoxylon formosum (Jack) Dyer.

Two trees of this species, in different parts of the Botanic Gardens, Singapore, have been kept under observation from 1927 onwards. As shown below, their periods have been closely similar, and on the whole very regular, averaging about 9 months, but the trees are quite apart in their dates of leaf-renewal. The behaviour of these trees is in my opinion one of the most remarkable examples in the series of observations recorded in this paper.

A tree of this species in the Waterfall Gardens, Penang, has been noted by me during visits in January and February 1931, 1932, 1933, 1935, 1936, 1937 and 1939. In each of these years the tree has renewed its leaves about the end of January (*i.e.* in the dry season). It is possible of course that this species is one that varies considerably in its leaf-periods from tree to tree, but the difference of behaviour in the seasonal climate of Penang seems to me likely to be significant.

The dates of leaf renewal of the Singapore trees have been as follows.

A		*B*	
	Months		*Months*
1. 9.27 ..	—	6. 2.28 ..	—
10. 6.28 ..	9·3	21.10.28 ..	8·5
17. 3.29 ..	9·2	30. 6.29 ..	8·3
23. 2.30 ..	11·2	7. 4.30 ..	9·2
27. 9.30 ..	7·2	12. 1.31 ..	9·2
1. 8.31 ..	10·1	11.10.31 ..	9·0
1. 4.32 ..	8·0	3. 8.32 ..	9·7
11.12.32 ..	8·3	16. 4.33 ..	8·4
13. 9.33 ..	9·1	1. 2.34 ..	9·5
end June 1934 ..	9·4	30.12.34 ..	10·9
25. 3.35 ..	9·0	12. 9.35 ..	8·5
16.11.35 ..	7·7	26. 5.36 ..	8·5
20. 9.36 ..	10·1	8. 3.37 ..	9·4
19. 7.37 ..	10·0	2.10.38 ..	2 × 9·4
8. 3.39 ..	2 × 9·9	10. 7.39 ..	9·3
Mean period: 9·1 months.		Mean period: 9·1 months.	
Extremes: 7·2 and 11·2 months.		Extremes: 8·3 and 10·9 months.	
Standard deviation: 1·09 month or 12·0%.		Standard deviation: ·74 month or 8·1%.	

Delonix regia (Boj.) Raf. (*Poinciana regia* Boj.).

An old tree of this species was under observation between 1928 and 1936, over eleven leaf-periods. As noted in my earlier paper, leaf-renewal is slow, and it is impossible to give accurate dates, or dates which are strictly comparable from one leaf-period to another. It is however evident that the mean period of the tree is in the neighbourhood of 9 months. After a lapse of 3 years without observations the tree was noted as in new leaf in June, 1939, which agrees with the last observations of July, 1936 (4 periods of 8·8 months occupying 2 years 11 months).

Trees of *Delonix regia* are commonly planted in Singapore, but even those planted simultaneously do not always keep in step together. It takes them a few years to develop a regular leaf rhythm, and this may perhaps change gradually with the age of the tree. Observations on this point, made on a group of young trees planted together, would be of great interest. It would be necessary however to treat all trees alike as regards cultivation (*see* Kigelia).

As noted in my earlier paper, some Delonix trees may be seen in flower at any time of the year in Singapore, but it appears that at some seasons flowering is more abundant than at others. Possibly the climatic conditions at the time when flower buds are produced may be responsible for this; *i.e.* it may be that trees which are bare during wet weather produce fewer flower-buds than those which are bare during dry weather. There is however no proof of this. At

Penang a Delonix tree renewed its leaves in January, 1931, 1932 and 1933. Further Penang records are desirable. The Singapore tree has renewed its leaves as follows.

	Months		*Months*
24. 6.28	—	Jan. 1933	10·
30. 3.29	9·2	Aug. 1933	8·
22.12.29	8·7	Mar.-Ap. 1934	8
10.11.30	10·6	Jan. 1935	8
1. 7.31	7·7	Sept.-Oct. 1935	8
March 1932	8·	July 1936	9

Mean period: 8·8 month.
Standard deviation: ·94 month or 10·7%.

Dyera costulata Hook. fil.

As reported in 1931, two trees of this species have been under observation. Leaf-renewal tends to be at rather irregular intervals, somewhat as in Hevea. On the big tree, which has two main trunks, leaves are sometimes renewed on a few branches only, or on one main branch system, between general renewals. New leaf growth occurring in the wet season (October, November) has in all cases preceded fall of the old leaves; at other times the old leaves have fallen before the new leaves began to unfold.

The big tree has had complete leaf-changes at intervals of from 3 to 11 months, sometimes with partial changes in between. Out of the 18 such periods, 9 have been about 6 months, 4 considerably less than 6, and 5 considerably more. A comparison with rainfall records indicates that there is some tendency for leaf-fall to follow dry weather; but this does not invariably occur. As above remarked, new leaves sometimes appear before the old leaves have fallen; in four such cases (all those noted) the period since the preceding leaf-fall was almost exactly six months. In other cases, under apparently similar conditions, no leaf-renewal has been recorded, and the old leaves appear to have persisted for 10 or 11 months (1931–32, 1934–35 and 1938–39). Where new leaves appear before leaf-fall, the old leaves are always shed within about two weeks following.

The smaller tree under observation (with one trunk) has changed its leaves rather regularly each year about March–June. In 3 years (1928, 1929, 1932) it has also changed again about six months later, but so far as my observations go, this has not occurred in other years. Taking only the changes in March to June, the mean period is 12·3 months, and the standard deviation ·84 month (6·8%). This tree also occasionally produces new leaves on a few branches without a general renewal. When new leaf growth was general in November, 1932 it was not preceded by leaf fall.

Dyera trees are fairly frequent in the Gardens Jungle, and they tend to change their leaves at the same time, though they do not always behave alike. The two trees under observation have changed their leaves simultaneously (or approximately so) on the majority of occasions, but on others have been curiously diverse in behaviour. The following are dates of general changes only.

Large Tree	*Months*	*Small Tree*	*Months*	
6. 9.27	—	17. 3.28	—	
17. 3.28	6·4	11. 9.28	5·7	
14. 6.28	2·9	14. 4.29	7·1	12·9
6. 4.29	9·7	3.11.29	6·7	
20.10.29	6·5	25. 5.30	6·7	13·3
25. 5.30	7·2	1. 6.31	12·2	
1.10.30	4·2	22. 5.32	11·7	
2. 6.31	8·0	3.11.32	5·4	
12. 4.32	10·3	21. 4.33	5·6	11·0
20.10.32	6·3	21. 5.34	13·0	
7. 8.33	9·5	25. 4.35	11·1	
21. 5.34	9·5	4. 5.36	12·3	
3. 5.35	11·4	14. 5.37	12·3	
9.11.35	6·2	23. 6.38	13·3	
31. 5.36	6·7			
3.12.36	6·1			
3. 6.37	6·0			
25. 9.37	3·7			
23. 6.38	8·9			

Erythrina lithosperma Miq.

Trees of this species in Singapore are remarkably constant in flowering in December and January, towards the end of the wet season. The trees are not deciduous, but this flowering appears to be connected with new vegetative growth which takes place early in the wet season, the onset of which is rather regular about October. I have no full record of the behaviour of one of these trees throughout the year, and only enter this observation here as the flowering of *Erythrina lithosperma* is one of the most regular seasonal phenomena in Singapore. The trees are not very showy nor abundant.

Fagraea fragrans Roxb.

As reported in this Bulletin, Vol. IX pp. 73–78 (1935), trees of this species, which are abundant in Singapore, flower gregariously about May every year. The trees are evergreen, and their vegetative growth is practically continuous, but their flowering is such a regular phenomenon that it should be mentioned here. The height of the flowering period, which lasts about 2–3 weeks, occurs

approximately four months after the end of the wet season, when the first dry period occurs. A week of dry weather, with no more than about ·1 inch of rain, following much wetter weather, appears to stimulate the formation of flower buds. Fruits ripen about 3½ months after flowering. There tends to be a small flowering about October–November, but this is irregular, and a few flowers may occur on isolated trees also at other times, but no general flowering of all trees.

Ficus caulocarpa Miq.

The tree reported upon in 1931 (under the name *F. glabella*) has been under observation since that time and has renewed its leaves three times each year, except 1935 and perhaps 1938, in which it changed four times. The causes of the length of the individual periods are doubtless complex, but it is fairly clear in a few instances that distribution of rainfall has had an influence. 1931 was a very wet year, and the long leaf-period was longer than usual; this was probably the cause of an unusually late first change in 1932. In 1934 December was unusually dry, and this probably accelerated the first change in 1935; but why the next period should have been so very short is not at all clear. In several years there is a definite succession of periods, approximately to 3, 4 and 5 months, but in other years this succession is much less distinct. The mean dates of leaf renewal (1928–37), are 12 February, 9 June and 8 November (giving intervals of 96, 117 and 152 days), the standard deviations being 19, 22 and 17 days; these deviations are distinctly high as compared with those shown by most of the deciduous trees here reported.

The amount of rain falling during a leaf-period bears no relation to the length of the period; I have also compared the rainfall from 14 days before the end of one period to 14 days before the end of the next, but this also shows no correlation with length of period.

Another younger tree, about a mile away, was under observation for a time, but probably not all changes were observed. Leaf-renewal dates were noted for this tree on 7 occasions between November, 1934 and June, 1937. The differences in time between the nearest leaf-renewals of the Gardens tree were 13, 23, 33, 32, 15, 13 and 53 days.

A young plant of the same species, which had started epiphytic growth on an old tree in the Gardens, changed its leaves once simultaneously with the large tree, but on two other occasions at times 40 and 41 days different.

It thus appears probable that the factors controlling leaf-fall and leaf-renewal in this species are complex and

vary from tree to tree. They are certainly not simply related to climatic conditions. It is possible that fruiting may influence the length of leaf-period; it seems to be rather infrequent, and the small figs are not easily observed on the high branches of the Gardens tree. Unfortunately I have no records of fruiting.

The dates of leaf-renewal observed are as follows:—

1927				15 Oct.
1928	29 Jan.	3 June		4 Nov.
1929	3 Feb.	17 May		20 Oct.
1930	23 Jan.	8 June		11 Nov.
1931	10 Feb.	28 June		2 Dec.
1932	12 March	1 July		9 Nov.
1933	16 Feb.	3 July		29 Oct.
1934	3 Feb.	19 May		2 Nov.
1935	20 Jan.	7 April	14 July	5 Dec.
1936	24 March	10 July		30 Nov.
1937	17 Feb.	27 May		20 Oct.
1938	unrecorded		20 Aug.	31 Dec.
1939	24 April	27 June	2 Sept.	
1940	25 Jan.	13 June		

Ficus variegata Bl.

This is a common species in Singapore, and seedlings are abundant in the Botanic Gardens. A tree was mentioned in my 1931 paper under the name *F. polysyce*.

This tree appeared at first to have a period of six months, but later proved to have a rather longer period, showing an average of 6·5 months, with standard deviation of ·84 or 12·9%. Its most peculiar behaviour was in 1932, when, having renewed its leaves in March, it persisted until November with the next crop of leaves, and then changed again in June 1933, the only leaf-renewal in that year.

A second tree, observed (with two gaps) from 1929 to 1939 was rather less regular, as shown below. Two other trees, observed only from 1932 and 1933, have shown greater regularity, with a less tendency so far to exceed a six months average. Mr. Corner has pointed out to me that the first mentioned tree is a male tree (figs contain male and gall flowers only) and one of the last two trees is female.

It was mentioned in 1931 that the male tree bore six crops of fruits in a year. The females trees under observation bear less frequent fruit crops (3 to 4 in a year), but in neither case could any relation between fruiting and leaf change be noted. The trees are cauliflorous, belonging to the subgenus Neomorphe. (For further information on this species, *see* Corner's paper in Journ. Malayan Branch

R. Asiatic Soc. XI: 48–52. 1933). The dates of leaf-renewal of the four trees and their leaf-periods in months are as follows:—

A	*Months*	*B*	*Months*
12. 8.28	—	25. 8.29	—
6. 1.29	4·8	2. 3.30	6·2
14. 7.29	6·3	7. 4.31	2 × 6·6
7. 2.30	6·7	Oct. 1931	6·
5. 8.30	6·0	22. 5.32	7·
8. 2.31	6·1	23.10.32	5·0
20. 8.31	6·4	Feb. 1933	4·
6. 3.32	6·5	27. 8.33	6·
Nov. 1932	8·	4. 3.34	6·2
11. 6.33	7·	18. 9.34	6·5
26. 1.34	7·5	31. 3.35	6·4
6. 9.34	7·3	Nov. 1935	7·
15. 3.35	6·3	June 1936	7·
Oct. 1935	7·	20.11.36	5·
April 1936	6·	1. 6.37	6·4
30.10.36	6·	13.12.38	3 × 6·1
12. 5.37	6·4	June 1939	6·
11.10.38	3 × 5·7		
11. 5.39	7·0		

C	*Months*	*D*	*Months*
21. 1.33	—	9. 8.32	—
25. 1.34	2 × 6·1	14. 1.33	5·2
15. 8.34	6·5	Feb. 1934	2 × 6·5
22. 1.35	5·2	21. 8.34	6·
19. 7.35	6·0	18. 2.35	6·
11. 2.36	6·8	6. 8.35	5·6
Sept. 1936	7·	22. 3.36	7·5
March 1937	6·	Sept. 1936	6·
end Aug. 1937	5·	30. 3.37	6·
		end Sept. 1937	6·
		30. 9.38	2 × 6·
		13. 3.39	5·4

Mean periods: *A*, 6·5; *B*, 6·4; *C*, 6·1; *D*, 6·1 months.
Standard deviations: *A*, ·84; *B*, ·85; *C*, ·65; *D*, ·62 month.
Coefficients of variation: *A*, 12·9%; *B*, 13·3%; *C*, 10·7%; *D*, 10·1%.

Heritiera elata Ridl.

A record of a leaf-period of nearly two years for a tree of this species was reported in my former paper. Subsequently there was a gap of four years in observations, and then three more periods, successively of 17, 22 and 20 months were recorded. The tree is usually not bare before new leaf-growth occurs; the new growth is conspicuous because of its pale colour. Flowering occurs on the old wood, usually during the period of new growth, but may perhaps (as with *H. macrophylla*) occur at other times. The tree is a very tall one, remaining from primitive forest. A young tree, about 100 yards away, was observed to make new growth at the same time as the old tree in 1940.

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The periods seem rather unequal in length, but the standard deviation is not excessive as compared with other trees. All recorded cases of leaf-renewal have occurred after unusually dry periods. This tree is probably one with a naturally long leaf-period (though the period is less than that of *H. macrophylla*) which is rather much influenced by climatic change occurring towards the end of its normal leaf-period. Observations of leaf-renewal are as follows.

	Months		*Months*
17. 3.29	—	March 1935	—
19. 2.31	23	Aug. 1936	17
		1. 6.38	22
		31. 1.40	20

Mean period: 20·5 months.
Standard deviation: 2·6 months or 12·7%.

Heritiera macrophylla Wall.

A small but quite vigorous tree of this species, which is native in Burma has been under observation since March 1929. It has an exceptionally long leaf-period, more than 2½ years on four successive occasions. Leaf-fall is prolonged over perhaps two months or more, at first slow, then progressively more rapid. Leaf-renewal is quite rapid, and is complete in a few weeks. In one case leaf-renewal took place on one branch after another over a period of six months instead of on all branches together.

It is notable that the Malayan species *H. elata* also has a long leaf-period. It would be interesting to have records of the widely distributed coastal tree *H. littoralis;* also to know something about the behaviour of *H. macrophylla* in its native climate.

The dates of leaf-renewal of the tree of *H. macrophylla,* and lengths of leaf-periods, are as follows.

	Months
30. 3.29	—
10.12.31	32
14. 7.34 to Jan. 1935 ..	31 (to 37 months)
18. 2.37	31
30.11.39	33·4

Hevea braziliensis Muell.-Arg.

The four trees mentioned in my earlier paper have been kept under observation since that time. Three of them illustrate the usual behaviour of Hevea trees in Singapore, namely response to dry weather whenever it comes, and consequent irregularity of leaf-renewal. The two larger trees have sometimes changed their leaves completely at the same time; sometimes a complete change

by one tree has been accompanied by a partial change in the other. The summary, printed below, though incomplete, gives a sufficient record to illustrate their behaviour.

One of the young budded trees, recorded in the previous paper as never undergoing a complete leaf change, but always changing leaves on a branch (or a few branches) at a time, continued to behave in the same way for some time afterwards. It was later once observed to change all its leaves simultaneously, but no full records have been kept. It may show a greater tendency to complete change as it grows older.

The other young budded tree, reported in 1931 as having renewed its leaves completely three times, has consistently continued this habit, with a period which appears to be significantly more than 12 months, the mean for nine periods being 13·3 months, with standard deviation of only 6·5%. The leaves of this tree are small, and it may be a morphologically distinct variety.

It is interesting to compare these observations with those of Schweizer (*Mitt. der Naturforsch. Ges. Bern,* 1932, pp. 1–8) at Djambi in Java, where there is a regular dry season. Leaf change of the Hevea trees at Djambi is related to the onset of the dry season, but some trees are always earlier or later than others in leaf-renewal. Characters of earliness or lateness are shared by all trees of the same clone. One tree was found to change its leaves frequently, a branch at a time; after manuring with Ammonium sulphate, the leaves all fell together, rather late, at the next dry season, but after two years the tree resumed its irregular habit.

Schweizer defoliated certain trees (the behaviour of which had been previously recorded) at various times in relation to the season of leaf-change. If the trees were defoliated more than 5 months before normal leaf-change, they produced new growth and the next change occurred at the usual time. If defoliation was carried out only 2–3 months before the date of normal leaf-fall, the subsequent leaves remained on the tree up to 3 months after the usual date of change. That is, the minimum life of Hevea leaves appears to be 4–5 months.

In Singapore, dry weather is irregular in its occurrence (*see* introductory remarks in this paper) and it seems probable that any dry period will affect some Hevea trees which have leaves more than 4–5 months old. If the dry weather is severe, all the leaves on the tree may fall; if not severe, only the oldest leaves. As there are few budded

trees in Singapore, the behaviour of the trees is very irregular, and after every dry period some trees may be seen with autumn colours or bare branches.

For other examples of irregular leaf-change, see *Sterculia carthaginensis* and *Mangifera indica.*

The single regular tree has shown the following succession of leaf-periods.

	Months		*Months*
22. 7.28	—	25. 2.34	15·0
1. 9.29	13·3	20. 3.35	12·8
22. 9.30	12·7	April 1936	13·
27. 9.31	12·2	7. 5.37	13·
27.11.32	14·0	8. 7.38	14·0

Mean period: 13·3 months.
Extremes: 12·2 and 15 months.
Standard deviation: ·86 month or 6·5%.

Partial or complete (full) changes of leaves of the two large irregular trees were observed as follows:

	Tree M	*Tree W*
1927	Nov. part	Aug. full
1928	..	March part
1928	Aug. full	Aug. part
1929	April part	March full
	Sept. part	
1930	March full	March full
1931	May part	July full
	Aug. part	
1932	March full	unrecorded
	Oct. part	
1933	Feb. full	Jan. full
	Aug. full	
1934	unrecorded	unrecorded
1935	Feb. full	
	Oct. full	Oct. full
1936	Aug. part	unrecorded
1937	March full	March full

Homalium grandiflorum Benth.

A tree of this species, which is native from Tenasserim southwards, has been under observation from 1932 to 1939, all leaf-changes except one having been observed. It will be seen that all periods were more than a year, the shortest being 12·5 months; one period of 17·5 months was however much longer than the others. It is not obvious why this very long period should have occurred. 1934 was a wet year (115 inches), but April, May and June, when leaf-fall might have been expected, were the driest months. Leaf-renewal took place after only 12·6 months on 30 December, 1936, though October and November had been wet months.

This tree flowers very rarely, with the new leaves.

Only one flowering was observed in the period under review. The observed dates of leaf-renewal are as follows:—

	Months		*Months*
8. 2.32	—	3.12.36	12·6
5. 4.33	12·9	18. 2.39 ..	2 × 13·3
20. 9.34	17·5	6. 3.40	12·6
14.11.35	12·8		

Mean period: 13·7 months.
Standard deviation: 1·9 months, or 13·9%.

Hymenaea courbaril L.

A fine tree of this West Indian species has been under observation since 1927 and was reported upon in my earlier paper. It is never bare of leaves, but it has produced new leaves regularly every year in January or February, simultaneously with the fall of the old leaves. Flowering follows, at the end of the new growth, in May or early June, and the fruits ripen and fall towards the end of the year. Exact dates are difficult to record with this tree, as new growth often begins on one branch and gradually spreads; but the tree is undoubtedly very regular in behaviour. There are indications that early or late ending of the wet season influence the time of leaf-renewal. Thus in 1928 wet weather persisted until February and new leaf-growth was not observed until 19th February. In 1930 new growth was observed on 12th January, following a dry December. In 1931 January was wet throughout, and the first new leaves were seen on 22nd February.

It is evident however that all trees of this species do not behave alike. In 1931 I reported on a tree that had flushes of new leaves on various branches in turn throughout the year, though occasionally renewing its leaves almost entirely at about the same time as the first tree. A third tree has since been noticed, which renewed its leaves in September 1935 and 1936. This tree renewed its leaves at the same time as the first, in February, 1940.

Kigelia pinnata DC.

A tree of this African species, reported upon in 1931, has continued very regular in its behaviour, renewing its leaves rapidly in January or February each year, the mean date being 22nd January. As will be seen below, the standard deviation is very small; this is particularly significant, as the time of leaf-renewal is more sharply defined than in some other trees, and so the dates are more strictly comparable. Leaf-fall is complete within a fortnight, and

new growth usually begins just before the tree is bare. Flowering takes place on the old wood, sometimes just before leaf-fall, but more usually within two months afterwards. The flowers (which are open at night) are regularly visited by the local bats, but fruits are not set very freely.

A very interesting comparison of behaviour is provided by some young trees, raised from seeds obtained from Africa. These trees were planted out, as young seedlings, on 19th October, 1931. They dropped their leaves and made new growth, in November, 1932, November, 1933 and November, 1934. Then in March, 1935 they were dug and manured, and they made new growth in April, dropping the old leaves soon after. Leaf-fall and new growth subsequently took place in April, 1936 and April, 1937. This appears to indicate that the species tends to keep very accurately to a 12–month period, but that stimulus to root activity may induce premature new growth. Schweizer found that manuring of Hevea trees affected their subsequent leaf-fall and leaf renewal (see *Hevea braziliensis*).

Though the first Kigelia tree has been very regular in its time of leaf-renewal, it has varied a little with the time of onset of drier weather after the wet season. Thus it was very early in January, 1935 after the unusually dry December, 1934.

	Months		*Months*
10. 2.29	—	14. 1.34	12·0
17. 2.30	12·2	5. 1.35	11·7
10. 2.31	11·8	13. 2.36	13·3
27. 1.32	11·5	5. 2.37	11·7
14. 1.33	11·4	15. 1.39 .. 2 ×	11·7

Mean period: 11·9 months.
Extremes: 11·4 and 13·3 months.
Standard deviation: ·57 month or 4·8%.
Mean date: 28 January.

Koompassia malaccensis Benth.

An old tree of this species, remaining from former primitive forest, was reported in 1931 to have renewed its leaves in three successive years in the month of September. This regularity subsequently changed, leaf-renewal being deferred until 8 November in 1930. In that year August was exceptionally dry, but there was a good deal of rain from September onwards, and possibly this wet weather was the cause of deferred leaf-fall. The next year leaf-renewal took place in December; then in 1933 there was no leaf-change at all, the next being in March, 1934.

After that there are two gaps in observations, dates noted being 17 May, 1936, 8 July, 1938, 15 June, 1939 and 12 May, 1940.

The mean period for 12 periods has been 12·7 months and the standard deviation not abnormally large; but I think that the incidence of dry weather or rain has considerable influence. Thus, once leaf-fall became deferred from September into the wet season, it became later and later, extending to March in 1934 when January and February were both very wet. In 1936 February was dry, but March very wet. New leaf-change is likely to continue about June and July, when fairly dry weather is frequent, for some years. If it does so, the mean period of 12·7 months will be seen to be too high. The rather early change in 1940 was probably due to unusual dry weather early in the year.

There is another tree of this species, beside a road outside the Gardens, doubtless also a relic of the former forest, which appears to have shorter and less regular periods, but I have not adequate observations on this tree.

The dates of leaf renewal, and the intervening periods in months, are as follows:—

	Months		*Months*
17. 9.27 ..	.. —	18. 3.34 ..	.. 14·8
11. 9.28 ..	.. 11·8	17. 5.36 ..	2 × 13·0
8. 9.29 ..	.. 11·9	8. 7.38 ..	2 × 12·9
21. 8.30 ..	.. 11·5	15. 6.39 ..	.. 11·2
8.11.31 ..	.. 14·5	12. 5.40 ..	.. 10·9
25.12.32 ..	.. 13·4		

12 periods.
Mean period: 12·7 months.
Extremes: 10·9 and 14·8 months.
Standard deviation: 1·36 months or 10·7%.

Lagerstrœmia flos-reginæ Retz.

The same two trees mentioned in my earlier paper were kept under observation until 1937. The older tree continued to renew its leaves first on the lower branches. The early stages of growth of new shoots are very gradual and it is not easy to fix exactly comparable dates, even for the same branch. Part of the variation shown therefore may be due to this cause; but still it is not larger than in a number of others.

The smaller tree continued as before to change the north side at a different time from the south, though the matter was later somewhat complicated by the development of a small central part which was more or less intermediate. The origin of this behaviour can probably be traced to the fact that when the tree was first planted a larger tree stood near it on the north side, shading that side considerably. The north side of the tree, as shown in the table below,

had a somewhat longer average period and a somewhat greater standard deviation. The two sides were near together in 1927 (only a month apart) but the north side gradually lagged behind, at the end of 10 years being six months later than the south side.

A number of young trees of this species were planted out by one of the roads in Singapore about 10 years ago. At first most of these trees flowered about the same time, but later flowerings have shown increasing differences from tree to tree. It seems probable that each tree, according to its nature and surroundings, develops a fairly constant period of its own, and that there are small significant differences of period from tree to tree.

A tree in Penang renewed its leaves in 3 successive years in January or February. It is likely therefore that this species is sufficiently influenced by the regularity of climate at Penang to change its leaves at the dry season every year. Further observations on this point are now in progress.

The behaviour of the two Singapore trees is indicated by the following data:

Smaller tree north side	*Months*	*Smaller tree south side*	*Months*	*Old tree*	*Months*
20. 8.27 ..	—	20. 7.27 ..	—	3. 9.27 ..	—
10. 6.28 ..	9·7	12. 5.28 ..	9·8	27. 5.28 ..	8·8
21. 4.29 ..	10·4	10. 3.29 ..	10·0	10. 3.29 ..	9·5
23. 2.30 ..	10·1	17.11.29 ..	8·2	17.11.29 ..	8·2
25.11.30 ..	9·	1. 9.30 ..	9·4	29.10.30 ..	11·4
6. 9.31 ..	9·4	3. 5.31 ..	8·1	15. 6.31 ..	7·6
5. 6.32 ..	9·0	12. 2.32 ..	9·3	27. 3.32 ..	9·4
12. 3.33 ..	9·2	20.11.32 ..	9·3	18.12.32 ..	8·7
1. 1.34 ..	8·6	30. 7.33 ..	8·3	24.10.33 ..	10·2
15. 4.35 2 ×	7·8	30.12.34 2 ×	8·5	15. 6.35 2 ×	9·8
20. 8.37 3 ×	9·4	8.10.35 ..	9·3	24. 2.36 ..	8·3
Mean period: 9·2 months.		9. 7.36 ..	9·0	Dec. 1936 ..	9·5
Standard deviation: ·88 months or 9·6%.		24. 2.37 ..	7·5	Oct. 1937 ..	10·
		Mean period: 8·9 months.		Mean period: 9·4 months.	
		Standard deviation: ·77 months or 8·7%.		Extremes: 7·6 and 11·4 months.	
				Standard deviation: ·99 months or 10·5%.	

Lecythis sp.

The tree of this species (probably *L. ollaria* L.) briefly reported upon in my previous paper has now completed 11 periods in almost exactly 11 years, with a standard deviation of only ·71 month; it is thus one of the most regular trees

under observation. The fluctuations from year to year are not large, the longest period being 13·3 months and the shortest 11 months. I can see no correlation between rainfall records and these late or early leaf-changes.

The leaves of this tree turn rather bright yellow quite suddenly, and are all fallen in 2–3 weeks. New buds begin to open as soon as the tree is bare, or sometimes before all the old leaves have gone. The dates given are therefore closely comparable. This tree has never flowered, though it is fully mature.

A small tree, probably of the same species, planted near the former tree on 24th February, 1928, renewed its leaves about February 1931, 1932 and January, 1933. Subsequently it was dug and manured (no exact records kept) on more than one occasion and subsequent changes were irregular. It will now again be brought under observation.

The dates of leaf change of the older tree are as follows:—

	Months		*Months*
8.7.28	—	16.9.34	12·3
18.8.29	13·3	21.8.35	11·2
8.8.30	11·7	28.8.36	12·2
30.8.31	12·7	29.7.37	11·0
16.9.32	12·5	20.7.38	11·7
7.9.33	11·7	30.6.39	11·3

Mean period: 12·0 months.
Mean date: 11 August.
Standard deviation: ·71 month or 5·9%.

Mangifera foetida Lour.

A tree of this species grows beside my house and has been under observation since 1927 except during absences in 1930, 1934 and 1938. It is not deciduous but has presented a rather regular behaviour as regards leaf-renewal and is worth recording. When new growth occurs, each twig produces either new leaves or flowers, or both. In one case only new leaves were produced and then a general flowering occurred three months later; in another case a general growth of new leaves followed a month after a general flowering. The usual procedure however is for leaves and flowers to be produced simultaneously, and the records below are for such (except that of 20th April, 1935 when no flowers were produced). It will be seen that the tree is less regular than some of the deciduous

trees, but has a standard deviation of only 11·6%, thus indicating the probability of a leaf-renewal not altogether dependent on climatic factors. The old leaves do not fall immediately the new begin to develop, as in *Mangifera indica;* an inspection of the tree shows that on some twigs leaves persist for at least 2½ years, while on others less than 18 months. The actual dates of general leaf-renewal are as follows:

	Months		*Months*
23. 9.27	—	26. 2.33	9·7
24. 6.28	9·0	5.11.33	8·3
3. 2.29	7·4	20. 4.35	17·5
18. 8.29	6·5	27.12.35	8·2
23. 3.30	7·2	1. 8.36	7·1
6. 9.31	17·5	1. 4.37	8·0
5. 5.32	8·0	23. 9.38	17·7

Assuming 16 periods: mean period is 8·25 months.
Standard deviation: ·96 month or 11·6%.

Mangifera indica L.

The two trees by the lake in the Botanic Gardens, mentioned in my previous paper, were kept under observation until 1937. After 1930 the trees rarely changed their leaves completely, but usually changed on a group of branches at a time. Change, whether partial or complete, usually took place simultaneously on the two trees, but sometimes one tree had a partial change, while the other did not. Leaf-fall always accompanies leaf-renewal, and never precedes it, so that the trees are never bare.

Flowering is rare, having occurred three times only in 10 years. There may have been a few flowers at other times, but no general flowering. As in other countries, flowering appears to be quite independent of leaf change. Flowering follows dry weather, but not all dry periods produce flowering.

It appears that the leaves usually last 9 to 12 months, but may exceptionally last only 4 to 5 months on part of a tree. The case is evidently a complex one, and needs more careful observation. Though the behaviour of these trees may seem to be rather like that of Hevea, in the Mangifera leaf-renewal precedes leaf-fall, whereas the fall comes first in Hevea. This may mean a quite different mechanism of response to climatic change, but careful analysis of the behaviour of the trees is needed before we can be sure of this. Mangifera trees would be interesting subjects for experiment on the lines indicated by Schweizer.

The following table summarizes the behaviour of the two trees from 1928 to 1937. "Full" means a complete leaf-change, "part" means leaf-renewal on part of the tree only.

	North tree	*South tree*	*Flowering*
1928 ..	July, full	July, full	
1929 ..	June, full	June, full	3.2.29
1930 ..	March, full	May, full	
1931 ..	end May, part July, part	end March, full July, part	
1932 ..	April, part Aug., part	April, part Aug., part	
1933 ..	Feb., part Aug., nearly full	Feb., part June, part Aug., part	26.2.33
1934 ..	no record	Nov., full	25.2.34
1935 ..	March, full end Oct. part	Aug., part Nov., part	
1936 ..	end March, almost full	end March, almost full June, rest of tree Sept., part	
1937 ..	Feb., part April, part	April, part	

Parishia Maingayi Hook. fil.

A tree of this species has been observed at leaf-change on five occasions, but not all consecutively. It appears probable however that the period is well over a year, in the neighbourhood of 15 or 16 months. I do not think it possible that the period is so short as half this, as the tree is in a fairly conspicuous place beside the potting shed at the Gardens, and though it was not on my regular list of trees, I could hardly fail to have observed it if it changed more frequently. It loses its leaves completely and stands bare for two weeks or more before leaf-renewal.

Herbarium specimens taken from the same tree prior to my observation of leaf-change indicate that the tree was flowering on the following dates: 25th April, 1923, 17th June, 1926 and 29th April, 1930. These specimens were probably taken about a month after the opening of the new leaf-buds. With this assumption, the dates in 1926 and 1930 agree with a leaf-period of about 15 months, but that of 1923 does not. The observed dates of leaf-renewal, and the estimated leaf-periods, are as follows:—

	Months		*Months*
20.10.32 ..	.. —	19. 5.39 ..	2 × 15·2
21. 7.35 ..	2 × 16·5	10. 8.40 ..	.. 14·7
10.11.36 ..	.. 15·6		

Probable mean period: 15·6 months.
Standard deviation: ·96 month or 6·2%.

Parkia javanica (Lam.) Merr.

The tree of this species mentioned (as *P. Roxburghii*) in my earlier paper has behaved in a more regular manner than any other of which records have been kept. Its inflorescences appear in September or October, after which leaf-fall begins slowly, being completed about the beginning of February, the fruits ripening at the same time. New leaf-growth begins after the tree has been bare for about a fortnight. The mean date of leaf-renewal is 23rd February, and the standard deviation only ·24 month or 7 days.

A very fine old tree of the same species in another part of Singapore has been observed in 1931, 1932, 1935, 1936 and 1937 to renew its leaves in March, about a month later than the tree in the Gardens. The data for the Gardens tree are as follows:

	Months		*Months*
27. 2.28	—	4. 3.34	12·3
27. 2.29	12·0	20. 2.35	11·6
17. 2.30	11·7	23. 2.36	12·1
19. 2.31	12·1	15. 2.37	11·7
21. 2.32	12·1	1. 3.39 ..	2 × 12·2
23. 2.33	12·1		

Mean period: 12·0 months.
Mean date: 23 February.
Standard deviation: ·24 month or 2·0%.

Peltophorum pterocarpum (DC.) Backer.

Two old trees of this species, mentioned in my earlier paper (as *P. ferrugineum*), have been regularly observed for 10 years, and have been very regular in their behaviour, the leaf-period averaging exactly six months, with standard deviation of less than half a month. The mean dates of 12th February and 10th August compare with 8th February and 11th August for *Terminalia catappa* over the same period.

The tree E mentioned in my earlier paper was evidently not in a vigorous state. Its leaf-changes were at rather long intervals (up to 9·5 months) and not at all regular. Observation of this tree was not continued.

The young tree F behaved much more regularly after the two short periods of 4·4 and 4·7 months in 1929–30. If the observations from 15th January, 1930 onwards are taken, the standard deviation is only ·75 month or 11·0%, which is not excessive; I think the short periods were due to attack by caterpillars. Possibly the tree will approximate to 6 months as it grows older. Compare the behaviour of the young tree of Couroupita.

As noted in 1931, this species flowers at the end of the vegetative growth, the fruits ripening about the time of

leaf-fall or somewhat earlier. Flowering is sometimes absent, but this does not appear to affect the length of the leaf-period appreciably.

The behaviour of this species in Ceylon and Java is evidently irregular (*see* my 1931 paper, p. 201, references to Wright and Coster). When I was in Bombay in October 1937, I noticed that all the trees bore fruits, the result of flowering earlier in the year, and that most bore also some flowers, though not a full flowering; but there was no sign of new leaves. The Superintendent of the Victoria Gardens at Bombay kindly informs me that the trees lose their leaves gradually from December to February and produce new leaves in March. They thus renew their leaves once a year, in contrast to *Couroupita guianensis*, which changes twice a year both in Singapore and Bombay. I noted that the Peltophorum trees of Bombay were much taller than those I have seen in Malaya, though I could otherwise see no difference. It is possible that the Malayan trees belong to a distinct race with the peculiarity of a tendency to a short leaf-period.

Two old trees

	Months
8. 1.28	—
24. 6.28	5·5
3. 2.29	7·3
21. 7.29	5·5
30. 1.30	6·2
8. 8.30	6·2
4. 2.31	5·9
23. 8.31	6·4
28. 2.32	6·2
11. 9.32	6·4
4. 3.33	5·8
26. 8.33	5·7
25. 2.34	6·0
25. 8.34	6·0
27. 2.35	6·1
22. 8.35	5·8
21. 2.36	6·0
28. 8.36	6·2
6. 2.37	5·3
10. 8.37	6·1
13. 7.38	2 × 5·6
20. 2.39	7·2

Mean period: 6·0 months.
Standard deviation: ·43 month or 7·2%.
Mean dates: 12 Feb. and 10 Aug.

Tree F

	Months
1. 4.28	—
11.11.28	7·3
14. 4.29	4·1
25. 8.29	4·4
15. 1.30	4·7
22. 7.30	6·2
10. 3.31	7·5
Nov. 1931	8·
26. 6.32	7·5
Feb. 1933	7·4
17. 9.33	7·
7. 1.35	2 × 7·8
20. 7.35	6·5
1. 3.36	7·4
2.10.36	7·0
20. 4.37	6·6

Mean period: 6·8 months.
Standard deviation: 1·27 months or 18·7%.
Mean period from 15.1.30 onwards: 7·3 months.
Standard deviation: ·75 month or 11·0%.

Pterocarpus indicus Willd.

There is a note about this species in my former paper (p. 202). I have little further to add concerning the periodicity of leaf-change of trees in Singapore. They are

certainly less regular and less free-flowering than in the seasonal climate of Penang; and trees in Singapore tend to change their leaves a branch or more at a time, often taking weeks or months to renew their leaves on all branches. Flowering follows new leaf-growth, and the extent of flower-bud production is probably influenced by climatic factors. Trees of this species in any one locality show a remarkable gregarious flowering which has been little noted in botanical literature.

The inflorescences develop up to a stage when the flower buds are well grown, and then rest for a time; then all buds which have reached this stage will suddenly flower, often making a most spectacular display, lasting only a day. The next lot of buds will go through the same process, each inflorescence flowering usually in two or three stages. It is a remarkable sight in Penang to see many trees clothed almost all over with gold; the flowers are small, and in a full display do not show individually.

The stimulus causing all buds at the receptive stage to develop is undoubtedly a fall of temperature, as in other cases of gregarious flowering (notably of the common orchid *Dendrobium crumenatum*). It appears that three days only are needed from the stimulus to the opening of the flowers. The stimulus may be a sudden fall of about 10° F., such as often accompanies a storm during the heat of the day; or a cool day, in which the temperature does not rise appreciably above 80° F.

All cases of flowering recorded by me in Singapore in the year 1940 (21 occasions) have followed three days after one or other of these temperature conditions. The sudden fall of temperature has ranged from 7° to 15° F. The largest flowering of all followed three days after a day of very uniform cool temperature.

As an indication of the slow rate of leaf-change, and the dispersal of flowering of one tree over considerable periods, the following case is of interest. A tree near my house bore flowers on 21 separate occasions between 9th April and 20th July, 1940. Most of these were only small flowerings, only two involving any large part of the crown of the tree. In the previous year (1939) the same tree flowered on 8 occasions in August and September. The biggest general flowering of trees in Singapore in 1939 was in June, and in 1940 on 30th May.

Salmalia malabarica (DC.) Schott & Endl.

The two trees reported on in 1931 (under the name *Bombax malabaricum*) have been kept under observation, and have continued to behave in a similar manner, the upper tree with a consistently longer period than the lower, as

shown below. The standard deviation of the tree with longer period (which is also the more vigorous of the two) is only ·44 month; of the other tree ·98 month. The trees always have a bare stage of 2–3 months irrespective of the time of year. Leaf-renewal has occurred in almost every month of the year.

It should be noted that these two trees are not growing under very favourable soil conditions and that their growth is poor. They will form interesting material for cultivation and manurial experiments (*see* remarks under Kigelia), which have now begun.

Upper Tree	*Months*	*Lower Tree*	*Months*
30. 3.28 ..	—	30. 3.28 ..	—
17. 2.29 ..	10·6	16.12.28 ..	8·5
18.12.29 ..	10·0	6.10.29 ..	9·7
1.11.30 ..	10·4	10. 6.30 ..	8·1
4.10.31 ..	11·1	3. 5.31 ..	10·8
1. 8.32 ..	9·9	6. 3.32 ..	10·1
4. 6.33 ..	10·1	1.12.32 ..	8·9
1. 5.34 ..	10·9	6. 8.33 ..	8·2
7. 4.35 ..	11·2	20. 4.34 ..	8·5
16. 2.36 ..	10·3	18. 3.35 ..	10·9
21. 8.39 ..	4 × 10·5	6.10.36 ..	2 × 9·3
		15. 7.37 ..	9·3

Mean period: 10·5 months.
Extremes: 9·9 and 11·2 months.
Standard deviation: (excluding 1936–39) ·44 month or 4·2%.

Mean period: 9·3 months.
Extremes: 8·2 and 10·9 months.
Standard deviation: ·98 month or 10·5%.

Saraca taipingensis Cantley.

A fine tree of this handsome Malayan species has been under observation for some years. The tree is evergreen, flowering on the old wood, independently of the production of new leaves. New leaves are produced in flushes at irregular intervals, but the old leaves do not immediately fall.

Though I cannot trace a definite connection between flowering and dry weather, it is fairly clear that flowering follows about a month or so after the beginning of a period of dry weather. The extent of the flowering naturally depends on how recently the tree flowered last. There are usually two fairly full flowerings in a year, and often small flowerings between. The flowerings recorded between 1927 and 1937 have been in the following months:—

January ..	Once	July ..	Once
February ..	Three times	August ..	Six times
March ..	Six times	September ..	Four times
April ..	Once	October ..	Twice
June ..	Once		

This indicates that the flowering tends to be in February–March and August–September, following the principal dry periods.

New leaves come in flushes at irregular intervals. As the old leaves do not fall when the new develop, the new growth is not dependent on the age of the old leaves. It seems to be most frequent soon after wet weather which follows a dry period, but this is not invariably the case, and the response is probably a rather complex one, dependent on the condition of the tree as well as on the weather.

Sindora Wallichii Benth.

The two trees of this species mentioned in 1931 have continued to behave irregularly as regards leaf-change, but records are incomplete. The tendency seems to be for a minimum leaf-period of about 12 months, with possible retention of leaves up to about 18 months. There is some indication that continued wet weather about 12 months from the last leaf-change prolongs the life of the old leaves; but the two trees do not always behave alike in this matter. Thus, they both renewed their leaves completely in February 1931; one tree renewed them again in February, 1932, though January, 1932 was not a very dry month, but the other delayed until August 1932 before renewal. The first tree had previously renewed its leaves in September, 1929, but failed to do so in September, 1930, though July and August were both unusually dry, deferring renewal until February, 1931.

The trees are slowly deciduous over a rather long period, and sometimes leaf-renewal occurs on part of the tree only, on other parts later. The response is evidently a complicated one.

Sterculia carthaginensis Cav.

The tree of this species mentioned in 1931 has been under observation since that time and has proved to be a very interesting case, comparable with that of Hevea, but less sensitive to climatic change. Its behaviour is worth considering in some detail.

The first leaf-renewal observed was on 11th December, 1927. The period from 12th November to 10th December was exceptionally dry, rainfall amounting to only 2·60 inches, instead of an average of about 10 inches. The next leaf-renewal was observed on 22 July, 1928, following a dry June. The next renewal occurred on 10th March, 1929; the rainfall in February was 10·97 inches, but there was a rather dry period from the 4th to 15th inclusive (12 days) with 1·00 inch, which may have caused leaf-fall to begin.

The weather was wet from August to November, 1929, December having only 4·49 inches. The tree had new leaves on a few branches about 10th December, but did not renew

all leaves until 17th February, 1930; the weather was dry from 12th January onwards (1–11th January, 3·17 inches; 12–31st January, 0·72 inch). It is strange that the two unusually dry months of July (1·89 inches) and August (1·13 inches) did not cause another general leaf-change, but there were small developments of new leaves at various times between August and November, 1930, (16th to 29th September and October 7th to 16th, were also dry periods). The next general leaf-renewal took place on 21st February, 1931; January was very wet up to the 19th, but from the 20th to 16th February the rainfall was only 1·80 inches. There was no more dry weather during the rest of the year (not more than six consecutive days without rain at any time) but a few new leaves were produced by the tree in December.

In 1932 the early part of January was dry (1–17th, ·56 inch), but leaf-renewal was deferred until 20th February. Following dry weather in July and August, there was occasional small leaf-renewal on various branches between July and October, but no general renewal until 16th January, 1933. There was hardly any wet season in the latter part of 1932, and only 1·19 inches rain from 3rd to 19th December; this presumably induced an early leaf-renewal in 1933.

In 1934 and 1935 there was again leaf-renewal in January, that of 1935 being early (12th) following a very dry December. There was an unusually large partial leaf-renewal on 18th September, 1935, about half the tree being involved; this followed a very dry July and August (2·73 and 3·03 inches). November and December, 1935, were wet, and also January, 1936; dry weather began on February 1st and a general leaf-renewal (involving the fall of those leaves produced in September, 1935) began on 3rd March, 1936.

The wet season at the end of 1936 was normal with a short break at the beginning of January, 1937, the rest of January being wet. Leaf-renewal occurred on 13th February. No further change occurred up to October, 1937. I have no record of the behaviour of the tree at the beginning of 1938. There was a dry fortnight in January and leaf-renewal probably took place in February. July was very dry with 2·4 inches and there was another dry period in October (2·7 inches in 24 days). It was presumably this which caused a complete leaf-renewal on 30 November. Though there was a good deal of dry weather in February and March, 1939, leaf-renewal did not occur until 8th May, a period of 5·3 months.

This tree is clearly unstable. It appears to have a minimum period of five months (5·5 months from the

half-renewal of 18th September, 1935 to 2nd March, 1936, and 5·3 months from 30th November, 1938 to 8th May, 1939) and a maximum of about 12 months (prolonged for some leaves to 13·7 months, on one occasion, following the large partial change of September, 1935). It appears that after about 5 months any pronounced dry weather may cause at least a partial leaf-fall, followed by leaf-renewal on the branches affected; leaf-renewal occurs a month or more after the onset of the dry weather (in a complete change, leaf-fall is complete in 2–4 weeks after the first signs of brown leaves). But it should be noted that where new leaves are produced on only a few small branches, these fall at the next general leaf-fall, even though this occurs only 2 or 3 months later.

The following table shows dates of complete changes only, with the intervening periods in months. For the years 1929–1937, the mean period was 12·1 months, with standard deviation ·88 month or 7·3%.

	Months		*Months*
11.12.27 ..	—	21. 1.34 ..	12·2
22. 7.28 ..	7·4	12. 1.35 ..	11·7
10. 3.39 ..	7·6	2. 3.36 ..	13·7
17. 2.30 ..	11·2	13. 2.37 ..	11·4
21. 2.31 ..	12·1	30.11.38 ..	2 × 10·8
20. 2.32 ..	12·0	8. 5.39 ..	5·3
16. 1.33 ..	10·9	22. 2.40 ..	9·5

Sterculia macrophylla Vent.

I have short series of records of three trees of this species, one in Penang and two in Singapore. Two of the trees have shown a fairly regular period of 6·4 to 8·2 months; the third tree was in poor condition, and much more irregular, in 1927–31. This third tree was subsequently cultivated and became more vigorous. It showed a period of 9·2 months in 1938–39. The records indicate this species as a short-period tree, both at Penang and Singapore. Its natural distribution is said to be confined to Malaysia. Records of its behaviour in the more strongly seasonal climate of East Java would be interesting. The following are data available for the three trees above mentioned.

Penang	*Months*	*Singapore*	*Months*	*Singapore*	*Months*
8. 1.31 ..	—	28. 2.35 ..	—	7. 9.27 ..	—
14. 9.31 ..	8·2	8. 9.35 ..	6·4	5. 8.28 ..	10·9
June 1932 ..	6·	30. 3.36 ..	6·8	1. 6.29 ..	9·9
3. 1.33 ..	6·5	20.11.36 ..	7·7	20. 6.30 ..	12·6
Aug. 1933 ..	7	27. 6.37 ..	7·2	2. 2.31 ..	7·4
				8.10.38 ..	—
				15. 7.39 ..	9·2
				13. 3.40 ..	8·0

Sterculia sp.

This tree, the species of which has not been identified, has been under observation for 12 years and has had a mean leaf-period of 10·1 months, with a good deal of variation. The standard deviation however is little more than 10% of the mean period. The data are as follows.

	Months		*Months*
16. 9.27	—	Dec. 1933 ..	2 × 9·5
12. 8.28	10·9	25. 8.35 ..	2 × 10·
1. 6.29	9·7	28. 5.36	9·1
14. 4.30	10·4	March 1937	9·5
5. 4.31	11·7	22. 8.39 ..	3 × 9·7
10. 3.32	11·2	21. 4.40	8·0
13. 3.33	12·1		

15 periods.
Mean period: 10·1 months.
Standard deviation: 1·26 month or 12·5%.

Tamarindus indica L.

The old tree mentioned in my paper of 1931 died not long afterwards. The young tree was kept under observation, but being planted in a clay soil was not in a very vigorous condition. It showed a tendency to have periods of less than a year for three years, but then had a period of 17·7· months, the subsequent leaf-growth being poor and slow in developing. In September, 1938, three months after a leaf-renewal, the tree was well dug and manured, new leaf-growth occurring two months later. The future development will be watched with interest. The dates of new leaf-growth are as follows.

	Months		*Months*
15. 2.31	—	15.12.34	10·
28. 2.32	12·4	4.12.35	11·7
24. 3.33	12·8	25. 5.37	17·7
15. 2.34	10·7	1. 6.38	12·2

Manured 18.9.38.
November 1938, more new leaves.

Terminalia catappa L.

Records have been continued of the behaviour of the tree mentioned in 1931. It has subsequently shown more irregularity than was indicated in the period 1927–31. This irregularity was chiefly in 1932–34, and is probably to be traced to the dry weather of August to December, 1932, which caused a leaf-renewal on 25th December, 1932, after a period of only 4·5 months. This was followed by three rather long periods, which brought the month of leaf-change to August once more. The long period of 1936 is surprising,

as the months of June, July and August were all fairly dry. New growth of leaf-buds is rapid and simultaneous all over the tree, so that dates are closely comparable.

As noted previously, this species changes its leaves twice a year in the strongly seasonal climate of east Java, in Ceylon, and in West Africa. In East Java it changes its leaves in the latter part of the wet season, and again in the latter part of the dry season. On the analogy of the behaviour of the Singapore tree, one would expect the leaf-periods in East Java ending February–March, during which the weather is much wetter than in the other period, to be longer, and the drier leaf-period, ending August–September, to be shorter. Records on this point would be interesting. It is clear that the species tends to have a leaf-period of about six months, and that the present tree is more sensitive to external influence than the tree of Couroupita, but less so than the trees of *Ficus variegata* mentioned in this paper.

At Peradeniya there are two dry seasons (one longer than the other) and the change occurs during the dry seasons. In Singapore the mean dates of leaf-change of the tree observed (8th February and 11th August) also correspond with the periods when dry weather is most frequently experienced.

Recorded dates of leaf-renewal of the Singapore tree are as follows.

	Months		*Months*
8. 1.28	—	11. 6.33	6·6
8. 7.28	6·0	21. 1.34	7·3
3. 2.29	6·8	20. 8.34	7·0
11. 8.29	6·3	28. 2.35	6·2
9. 2.30	6·0	10. 8.35	5·5
8. 8.30	6·0	18. 2.36	6·3
6. 2.31	6·0	20. 9.36	7·1
20. 8.31	6·5	12. 3.37	5·6
6. 2.32	5·5	9. 9.37	5·9
9. 8.32	6·1	1. 9.38 ..	2 × 5·9
25.12.32	4·5	15. 3.39	6·5

Mean period: 6·1 months.
Extremes: 7·3 and 4·5 months.
Standard deviation: ·64 month or 10·5%.
Mean dates: 8th Feb. and 11th Aug.

Terminalia subspathulata King.

This local species is represented by a fine tree on the edge of the Gardens Jungle in Singapore. This tree has been very regular in its behaviour since 1928. It begins to lose its leaves about October and loses them slowly all through the wetter season, more rapidly when the drier weather begins in January or February, and is nearly bare

for perhaps a month before the new buds begin to open. The opening of the buds is quite rapid and simultaneous all over the tree, so that dates are closely comparable. Flowering does not occur every year.

The factors which influence the date of leaf-renewal are probably rather complex, as the period of leaf-fall extends over several months. There is little doubt that the tree has a natural tendency to a 12-month leaf-period, and also that the occurrence of the bare period immediately following the break at the end of the wet season is significant; but the slow loss of leaves through the wet season is curious. The data for this tree are as follows.

	Months		*Months*
19.4.28	—	10.5.34	13·3
17.3.29	10·9	27.3.35	10·6
16.3.30	12·0	10.4.36	12·5
31.3.31	12·5	29.4.37	12·6
10.4.32	12·3	12.4.39 .. 2 ×	11·7
2.4.33	11·7	12.3.40	11·0

Mean period: 11·9 months.
Standard deviation: ·83 month or 7·0%.
Mean date: 6th April.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1927

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	3·94	2·07	—	·70	·01	—	—	—	—	2·45	—	·09
2	·91	·40	—	·01	·70	—	·02	—	·02	·40	1·15	·24
3	·24	1·22	—	·01	1·60	·01	1·31	·13	·08	·20	·20	·08
4	·06	·05	·99	·03	·66	·25	·06	—	—	·91	—	·06
5	—	·07	3·76	·07	—	·16	·52	—	1·31	—	·50	·01
6	·01	·07	·29	—	—	—	·10	·11	—	·50	·31	·09
7	—	—	·27	—	·57	—	·01	·07	—	·17	·08	—
8	·02	—	·31	·06	·03	—	·13	—	—	·56	1·13	·01
9	·14	—	1·21	·13	1·39	·45	·04	—	—	·36	·71	—
10	·99	·01	·02	·30	—	1·39	·89	—	—	—	—	—
11	·03	·31	—	—	—	—	—	—	—	—	3·18	1·52
12	1·27	·12	—	—	·62	·11	·03	·27	·14	—	—	·59
13	—	·15	—	1·64	—	—	—	—	·03	·01	·02	·21
14	1·01	·19	—	—	—	—	—	·01	—	—	·01	·07
15	2·35	·03	·11	—	·45	—	—	—	—	·11	·27	—
16	·06	1·29	—	—	·07	—	·29	·02	—	—	—	·15
17	·18	—	—	·08	·28	·03	·41	—	·44	—	·13	—
18	—	—	·21	·14	·26	—	·07	—	—	—	·01	·01
19	1·41	—	2·89	1·89	—	·05	—	—	·09	—	·05	—
20	·21	·60	2·01	1·47	1·12	·12	·10	·92	—	—	·04	·08
21	·08	·82	·06	·13	·23	·38	—	·19	·03	—	·13	·02
22	—	·20	·05	1·27	·13	·04	—	1·46	·46	·16	—	·04
23	·06	—	1·87	·55	—	·13	—	1·31	·07	—	·07	·49
24	1·37	·01	·04	·84	—	—	—	—	·54	—	·99	2·59
25	·01	—	·06	·89	·03	·37	—	·04	·06	·22	·13	·01
26	—	·01	—	·16	·02	·15	—	—	1·22	·34	·12	3·67
27	—	·95	—	—	·21	·94	—	·80	·36	·70	·01	·51
28	1·68	2·40	·09	·06	—	—	—	·04	·02	·01	—	·57
29	·62		—	1·72	·76	—	—	—	—	·03	·04	·22
30	·03		·41	·68	—	—	—	—	·78	·35	—	—
31	1·64		2·15		—		—	—		·49		·02
	18·32	10·97	16·80	11·83	9·14	4·58	3·98	5·37	5·65	7·97	9·28	11·35

Total for the year: 115·24 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1928

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	·01	—	—	1·70	—	—	—	·21	—	·84	1·11	—
2	2·04	1·07	—	—	—	—	—	—	—	·03	·67	·25
3	1·37	·16	—	—	—	—	·09	1·37	1·23	·10	1·36	—
4	·01	·06	—	—	—	·35	—	—	—	—	—	·07
5	·09	—	—	·92	—	—	·52	—	—	·24	·03	·78
6	·75	—	—	·08	·29	·08	—	·06	—	—	1·39	—
7	·20	2·02	—	·93	—	—	1·16	·04	·26	·38	—	·90
8	·03	—	—	1·68	·95	—	—	—	·40	—	·21	·65
9	1·00	—	—	·45	1·25	·16	—	—	·33	·36	2·00	1·51
10	·58	—	1·52	·98	—	·35	·89	—	—	—	1·65	·32
11	·48	·42	—	—	—	—	2·04	·65	—	·06	—	—
12	4·08	1·06	—	·06	·39	—	·19	—	·06	—	·03	—
13	·02	—	—	·65	·02	·08	—	·61	2·56	—	1·39	·41
14	·76	—	—	—	—	1·54	—	·09	·59	·03	·20	·17
15	—	·50	·09	1·14	—	—	—	—	·32	·15	·15	·26
16	—	·57	·02	·29	·15	—	—	·62	·18	·18	1·41	1·25
17	—	·26	·25	—	—	—	—	—	—	2·46	4·29	·71
18	—	·02	1·29	—	·20	—	—	—	—	·41	·26	—
19	·06	·01	1·17	1·05	—	·31	—	1·11	—	·13	·18	—
20	·02	·55	—	1·32	—	—	—	·30	—	1·04	·59	—
21	·06	—	·50	—	—	—	—	—	·48	·15	—	·03
22	·50	—	1·10	—	—	—	—	—	1·62	—	—	·47
23	·71	·41	—	·55	—	·65	—	—	—	·31	—	·22
24	·08	3·02	—	—	·13	—	—	1·75	1·14	—	·13	—
25	1·20	·16	·16	—	—	—	—	1·25	—	—	·19	·01
26	·15	—	·01	—	—	—	—	·72	—	·61	—	·17
27	·01	—	2·01	·07	—	—	—	·15	·02	—	—	—
28	—	1·05	·12	—	·37	—	·12	—	—	—	—	1·44
29	—	·15	·51	—	·08	—	—	1·42	—	—	·44	·23
30	·08		—	—	·10	·18	—	—	·61	—	—	—
31	—		—		—		2·32	·39		—		·43
	14·29	11·49	8·75	11·87	3·63	3·70	7·33	10·74	9·80	8·08	17·68	10·28

Total for the year: 117·66 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1929

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	·96	·65	—	·06	—	·09	—	—	·10	—	·46	·14
2	·68	1·70	—	·77	—	—	—	—	—	—	—	·45
3	—	—	—	—	·16	—	—	—	—	—	—	·23
4	—	·14	—	·06	—	—	—	—	·07	·10	—	·04
5	2·48	·33	—	—	2·85	·73	—	—	·64	—	—	·27
6	·30	·29	—	—	·21	·03	—	—	·11	1·30	·49	·01
7	—	—	—	—	—	·09	—	—	·05	·15	—	·08
8	—	·08	—	—	·16	·30	—	—	—	—	·01	·11
9	—	—	—	—	—	—	—	—	—	·30	·12	—
10	—	—	1·95	—	—	·37	—	·20	·05	·19	2·30	—
11	—	1·67	·20	—	—	—	—	1·61	—	·67	·06	—
12	·15	·05	·13	·62	·56	·02	—	1·31	·70	—	·14	—
13	—	·25	·11	—	·27	—	·28	—	—	·08	·27	—
14	·10	—	·20	·01	·34	—	—	—	·11	—	2·56	—
15	—	·91	·21	·01	—	—	·31	·07	—	·03	·14	—
16	·16	—	—	—	—	·22	·64	—	·50	—	·01	·29
17	·16	·13	·01	·02	—	—	—	—	·21	—	—	·56
18	—	·14	·03	—	—	—	—	—	—	—	1·65	—
19	—	—	·68	·09	—	·73	·08	—	—	·52	·33	—
20	—	—	·18	·10	1·26	—	·09	—	·05	·24	—	·56
21	—	·94	—	—	—	—	·12	—	—	—	·46	·23
22	·23	—	—	—	—	—	—	—	—	·19	—	·11
23	—	—	—	—	—	—	—	—	·02	·06	·06	—
24	—	·67	—	·34	·07	·45	—	·37	—	—	—	—
25	—	—	·81	—	—	1·72	·63	·34	—	2·06	—	—
26	—	·57	1·96	·14	·92	·82	—	—	·05	—	·51	·02
27	—	·47	·57	—	·28	—	—	·09	—	·10	—	—
28	—	—	·04	—	·22	2·52	—	—	·13	1·56	—	·92
29	—		—	·29	·13	·02	—	·07	5·80	·25	1·96	—
30	—		—	—	—	—	—	1·93	·45	·18	·08	·31
31	—		1·98		1·24		—	1·98		·33		·16
	5·22	8·99	9·06	2·51	8·67	8·11	2·15	7·97	9·04	8·31	11·61	4·49

Total for the year: 86·05 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1930

—	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	—	—	—	·16	·24	—	—	—	·02	—	1·34	1·44
2	—	—	—	—	1·42	—	—	—	—	·06	—	—
3	·09	—	—	—	·51	—	—	—	—	—	·04	·09
4	1·12	—	·01	·52	2·27	—	—	—	—	·09	·20	·27
5	·35	—	—	2·48	—	—	—	—	·19	·08	·56	·83
6	—	—	—	2·62	—	·12	·28	·18	—	1·13	·48	—
7	·06	—	—	·13	·03	—	—	—	1·95	—	—	·03
8	—	—	·40	—	·91	—	—	—	—	—	·01	·88
9	—	1·84	—	—	·19	—	—	—	—	—	—	—
10	1·13	1·91	·86	·02	·07	—	—	—	—	—	—	—
11	·42	—	·35	1·70	1·29	3·79	—	·24	·05	—	—	·17
12	—	—	·58	—	·25	—	·01	—	·02	—	·02	·55
13	—	—	—	—	—	—	·10	—	1·29	—	—	—
14	·04	—	·15	1·34	—	1·38	—	·06	—	·25	·03	·43
15	·10	—	1·79	·09	—	—	—	—	·56	—	—	1·47
16	·30	·05	—	—	—	·11	—	—	—	—	·02	·31
17	—	·03	1·31	—	·67	5·48	—	·22	—	1·33	2·38	—
18	—	·16	·13	—	—	1·01	—	—	—	1·57	1·65	·80
19	—	—	—	·24	—	·22	—	—	—	·07	·08	·13
20	·07	—	—	·16	·67	·11	—	·01	—	—	·03	·50
21	—	—	—	·84	—	—	—	—	—	·25	·09	—
22	—	—	·13	·57	—	·31	—	—	—	·40	·39	·53
23	—	—	—	·26	—	—	·36	—	—	·21	—	—
24	—	—	—	3·37	1·83	—	·30	—	—	·72	·18	—
25	—	—	—	—	·17	—	—	·31	·24	1·65	—	·89
26	—	·10	—	—	—	—	—	·11	·23	·20	—	·01
27	·21	—	—	—	—	—	—	—	—	—	·56	·09
28	—	·29	—	—	—	—	·63	—	—	—	2·33	·02
29	—		—	—	—	—	·14	—	2·50	·13	·15	·16
30	—		—	—	—	—	·07	—	·13	·23	·29	·07
31	—		—		—		—	—		·64		·41
	3·89	4·38	5·71	14·50	10·52	12·53	1·89	1·13	7·21	9·01	10·82	10·08

Total for the year: 91·67.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1931

—	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	·41	—	—	·12	·04	·01	1·43	—	—	·07	·85	·68
2	·13	—	·04	·10	—	—	·03	—	—	1·28	·09	—
3	·47	1·01	·21	·85	·35	1·33	·63	—	·05	—	·02	—
4	·02	—	—	·01	·35	2·12	·07	—	—	·43	·16	·04
5	—	—	·49	1·90	—	·22	—	·67	—	—	1·73	·17
6	·66	—	·06	—	—	—	—	—	·02	—	—	2·61
7	·16	·29	·16	·34	—	—	·82	—	—	—	2·59	—
8	·08	—	—	—	·21	—	—	·24	—	—	—	·02
9	·03	—	—	·32	—	—	·41	—	·19	1·17	·78	·48
10	·14	—	·81	—	·40	—	—	—	—	·49	—	·01
11	·30	—	·40	·64	·09	·67	—	—	·23	—	·79	·12
12	1·67	—	1·04	—	1·43	—	—	1·61	·10	·30	·26	·15
13	1·20	—	—	—	·14	—	—	·03	·03	—	·11	·11
14	1·41	—	·34	·02	—	·08	—	·29	·88	—	—	·54
15	1·44	·12	—	·08	—	—	—	·14	—	—	—	·26
16	·51	·03	—	—	—	—	—	—	1·01	·05	—	·11
17	·19	2·23	—	—	1·48	—	—	—	—	·06	1·16	·16
18	1·21	·02	—	1·31	—	·03	—	—	—	—	·04	—
19	·76	—	·02	—	—	—	·05	—	1·69	—	1·08	·45
20	—	—	·24	—	—	—	—	—	·06	·64	—	—
21	·08	—	·01	·21	—	·29	1·37	—	1·54	—	—	—
22	·10	—	1·52	—	1·02	·42	—	·07	2·09	·71	—	·10
23	·57	—	—	·39	·09	·46	—	—	·06	·19	·06	·25
24	·36	1·02	—	·22	—	1·39	·47	—	1·09	—	·71	2·56
25	—	—	—	—	—	·51	—	—	—	—	·35	·79
26	—	—	—	·21	·99	—	2·39	1·89	—	·31	1·08	·80
27	·24	—	—	·29	·07	—	—	·21	—	—	—	·36
28	—	—	—	·24	·18	—	·17	·23	·12	1·32	·76	·13
29	—		·28	·31	2·14	—	·34	·82	—	—	·90	—
30	—		·65	—	—	—	—	—	·42	1·28	—	·57
31	—		1·27		·12		·41	·01		—		·07
	12·14	4·72	7·54	7·56	9·10	7·53	8·54	6·21	9·58	8·30	13·52	11·54

Total for the year 109·28 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1932

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	—	—	1·27	·04	·89	—	·66	—	—	—	·37	·02
2	—	—	—	·96	·01	—	1·63	—	·10	·22	·16	2·10
3	—	—	—	·40	—	—	—	·22	—	—	—	·08
4	—	—	—	—	·95	·48	·01	—	·87	—	·03	·31
5	—	·03	—	·40	—	—	·02	—	·35	—	·24	·05
6	·31	—	—	—	—	·88	1·23	—	—	—	—	—
7	·12	·29	—	·70	·22	—	2·10	—	—	—	—	·07
8	—	—	—	·36	1·51	·39	2·88	—	·31	—	·13	—
9	—	—	—	·05	—	—	—	·03	·17	—	·14	·51
10	—	·21	—	·75	—	·14	2·40	—	—	—	1·76	—
11	—	—	—	—	—	—	·14	—	3·25	—	·71	—
12	—	—	—	—	1·81	—	—	—	—	·60	·34	·01
13	—	—	·01	1·06	—	—	—	·09	—	·11	—	—
14	·13	—	·04	—	—	·02	—	—	—	—	—	·16
15	—	·83	—	·06	—	·06	—	·04	·22	—	·62	—
16	—	—	—	·03	·03	—	—	·02	—	·02	·04	—
17	—	—	—	·10	—	·20	—	·07	·52	—	—	—
18	·51	—	—	·11	·54	·03	—	·29	—	·11	·32	—
19	—	1·25	—	—	—	—	—	·05	—	·07	·02	—
20	·37	·60	·06	—	·05	·16	—	·08	—	—	·03	·95
21	1·11	1·02	·72	·47	·24	—	—	·10	—	·09	—	—
22	1·14	·12	1·94	—	—	·70	·40	—	·05	—	—	·15
23	·23	—	·60	·38	2·67	—	·55	—	·20	—	—	·23
24	·03	·31	·56	—	3·94	—	—	—	1·85	·33	—	—
25	·01	—	—	·04	·31	—	—	·12	—	·28	—	·09
26	1·14	·24	1·02	—	—	1·89	—	·19	—	—	·13	·29
27	1·09	—	·12	·13	—	·08	—	—	—	1·04	—	·17
28	·35	—	—	—	·17	—	·07	·41	·09	—	—	1·20
29	—	—	·33	—	—	—	—	·12	·54	·36	—	·20
30	·13		·03	—	1·28	—	—	—	·02	·02	·15	—
31	—		—		—		1·90	—		·04		—
	6·67	4·90	6·70	6·04	14·62	5·03	13·99	1·83	8·54	3·29	5·19	6·59

Total for the year 83·39 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1933

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	—	—	·78	·57	—	—	—	—	·03	—	—	·02
2	—	1·93	1·14	·82	—	—	1·47	—	·74	—	·24	·25
3	2·82	—	—	—	—	—	·08	—	—	—	·28	·02
4	·93	—	—	—	—	—	1·48	—	—	—	·10	—
5	·15	—	·28	—	—	—	—	—	—	·39	·41	—
6	·48	—	·06	1·10	—	—	—	—	—	·11	—	·05
7	·20	—	·39	·04	—	—	2·21	—	—	·49	·06	·47
8	·09	—	1·87	·03	—	—	2·06	·20	·76	4·40	·25	—
9	—	—	1·17	·26	·06	—	·73	—	1·28	—	—	—
10	—	—	1·79	—	—	·07	—	—	—	·45	—	·63
11	—	—	·72	—	—	·59	—	—	—	·41	—	—
12	·71	—	·52	—	·11	·27	·34	—	—	·20	·02	·66
13	—	—	—	·36	·03	·22	·23	·10	—	·12	—	·73
14	—	—	·03	·25	·31	1·05	·38	1·10	—	—	1·33	—
15	—	—	—	·21	·06	—	·23	—	—	—	·03	·33
16	—	—	—	·12	—	—	·39	—	·46	·03	·07	—
17	—	—	·19	·23	1·16	·08	—	·52	—	—	—	—
18	·87	—	—	·41	·21	1·09	—	·23	—	—	·14	·25
19	·64	—	·07	—	—	1·89	—	—	·28	—	3·59	·27
20	1·18	·40	—	·12	·25	·03	·10	·32	—	—	·15	—
21	·34	—	—	—	·05	—	—	·62	·25	—	1·23	—
22	·09	—	—	—	70	—	—	—	·42	—	—	·58
23	—	—	·04	—	·02	—	—	—	1·10	·15	2·01	·24
24	·28	—	·10	·02	·04	—	—	—	·24	·30	—	·67
25	·75	·05	—	·68	—	—	—	·04	·44	—	—	1·38
26	·04	·83	·14	·57	·79	—	—	·08	1·03	—	·14	·42
27	—	·66	—	—	—	·01	—	—	·21	·24	1·62	—
28	—	·25	·07	—	—	—	—	—	·02	—	—	—
29	—		—	1·15	—	·23	·24	·25	·21	2·08	·35	—
30	—		—	—	1·37	—	—	3·15	1·23	·19	·03	—
31	—		1·24		—		1·38	—		—		—
	9·57	4·12	10·60	6·94	5·16	5·53	11·32	6·64	8·70	9·56	12·05	6·97

Total for the year 97·16 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1934

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	—	—	·30	—	·02	—	—	—	1·82	—	1·88	·06
2	—	—	·22	—	·08	1·69	—	—	2·57	—	·26	—
3	·10	—	·75	—	1·01	·05	—	—	·44	—	—	·66
4	·45	·19	·10	—	·10	—	—	·06	·09	—	·03	·51
5	·03	·48	·02	·09	·37	—	—	—	·87	—	—	·03
6	3·70	·04	1·00	—	—	—	—	·18	—	—	·24	·33
7	6·90	1·02	1·89	·02	—	—	—	—	—	—	—	·26
8	2·52	—	4·83	—	—	—	—	—	—	·21	·45	—
9	—	·03	—	—	—	—	·08	—	—	·30	·16	—
10	·10	·60	·71	·02	·06	·46	—	—	—	—	·06	—
11	·11	·42	—	1·10	·85	·20	—	·08	—	1·24	·61	—
12	·10	1·00	·85	·05	—	·39	·39	—	—	·21	—	—
13	·25	—	·04	·95	—	·02	—	·06	—	·01	1·16	—
14	·70	—	·05	2·10	—	—	2·35	—	—	·70	1·92	—
15	·16	—	·25	—	·27	—	1·91	—	—	·15	·94	—
16	4·45	1·82	·21	·20	2·45	·06	—	—	—	—	·41	—
17	·25	—	·58	—	·73	·04	·76	1·71	1·20	3·02	·26	·01
18	·02	·81	—	—	—	·11	·59	·04	—	·02	·37	—
19	·01	—	·06	—	—	—	·32	1·04	—	·12	·28	—
20	2·50	—	—	—	—	·02	·96	—	—	—	—	—
21	·11	—	·25	·84	—	·71	—	·03	·99	—	·07	—
22	—	—	·71	—	—	—	1·23	·23	—	·10	·02	—
23	—	·40	—	—	—	·16	·07	—	·03	—	—	—
24	—	—	·05	—	—	·15	·33	—	—	—	4·02	·06
25	—	·50	—	—	—	1·60	·40	·42	—	—	—	—
26	—	—	·27	—	—	·09	1·81	·34	—	—	—	—
27	—	—	·47	·14	—	—	·48	—	—	—	·24	—
28	—	—	—	—	—	—	—	—	—	2·16	·44	·25
29	—		—	·26	·16	—	—	—	—	·02	·46	·21
30	—		—	·04	—	·32	—	—	·04	·12	·69	—
31	—		·26		—		—	3·56		—		·20
	22·46	7·31	13·87	5·81	6·10	6·07	11·68	7·75	8·05	8·38	14·97	2·58

Total for the year 115·03 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1935

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	—	—	·44	—	1·01	1·82	—	—	—	—	—	·92
2	—	—	·17	—	·16	·30	·90	—	—	·02	—	·52
3	1·45	—	·86	·66	—	·81	—	—	—	—	2·91	·28
4	·06	—	—	—	·46	·05	·14	—	—	—	1·11	—
5	·29	—	—	·06	—	—	—	—	—	—	·02	—
6	·58	—	·81	·02	—	·53	—	—	—	·29	—	·01
7	3·61	—	·07	—	1·73	—	—	—	—	—	·91	·03
8	1·37	—	·04	—	—	·21	·57	—	—	—	·10	—
9	—	—	·03	·13	—	—	—	—	·92	·04	—	1·33
10	—	—	·06	—	—	1·34	—	1·07	—	—	·30	—
11	—	—	·39	·25	1·70	—	—	—	—	—	—	—
12	—	—	—	·13	—	—	—	·23	—	—	·04	—
13	—	—	—	·42	—	—	·11	·26	·31	—	·91	1·56
14	·95	—	—	1·60	·14	—	—	·15	1·63	—	·23	1·86
15	—	·25	·14	·45	·28	·08	—	—	—	·21	—	1·74
16	—	1·17	·62	·02	1·08	·08	—	—	—	·22	·15	—
17	—	1·65	2·90	·06	—	·02	—	—	—	—	—	—
18	—	1·24	—	—	·02	—	—	·26	—	—	—	—
19	—	·15	—	—	—	1·12	—	·03	—	—	·33	·12
20	·16	·11	·13	·73	—	—	—	—	—	·59	·30	·09
21	—	·26	·37	—	·01	—	—	—	—	·14	—	·03
22	3·10	—	—	—	1·30	·59	—	—	—	·16	1·62	·38
23	·55	—	—	—	—	—	1·01	·31	—	·50	·02	1·71
24	—	—	·22	·02	·45	—	—	—	—	—	·10	·01
25	—	—	—	—	—	1·57	—	·02	·37	·26	—	·17
26	—	—	1·61	—	—	·14	—	—	—	1·68	·32	·57
27	—	—	·30	—	—	·05	—	·15	·29	·51	1·28	·13
28	—	—	1·02	—	—	—	—	·33	·13	—	·95	·02
29	—		—	·06	—	—	—	·21	·02	—	·03	1·32
30	—		—	·18	—	·07	—	—	—	—	·24	·33
31	—		—		—		—	—		—		1·35
	12·12	4·83	10·18	4·79	8·34	8·78	2·73	3·02	3·67	4·62	11·87	14·48

Total for the year 89·43 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1936

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	·24	—	—	·29	—	—	—	—	—	—	—	—
2	·01	—	—	·93	—	—	·09	·09	·05	—	·81	1·22
3	·09	1·43	—	—	·28	·07	—	—	—	—	1·38	·04
4	·02	—	—	—	·90	—	—	·14	—	1·09	—	·01
5	·99	—	·42	·24	—	—	·06	—	—	—	—	·61
6	·70	—	·32	·49	·24	—	—	·17	—	·57	·21	·28
7	·07	—	—	1·07	—	—	—	·04	—	—	·21	—
8	—	·04	—	—	·89	—	—	·71	·05	·31	2·48	—
9	—	—	—	—	·09	—	2·74	—	—	1·33	·84	·21
10	—	—	—	—	·89	—	—	·14	—	·36	—	·25
11	2·44	—	·93	·07	·13	·33	—	—	—	·61	—	—
12	·74	—	·64	·44	—	·21	·74	—	—	—	—	—
13	—	·04	·32	·07	·46	—	—	—	—	—	·04	—
14	·04	·06	2·42	·47	—	—	—	·43	·06	—	1·05	—
15	·21	—	·16	·32	·39	—	·83	—	—	·17	—	·13
16	—	—	·42	—	·32	·29	—	·14	·14	—	—	·70
17	·03	·02	·11	—	1·24	—	—	·72	—	—	—	—
18	—	—	·67	—	—	—	—	·08	—	·73	2·72	3·38
19	—	—	—	·45	·10	—	—	·43	—	·20	·39	—
20	·01	—	—	—	1·00	—	—	·04	·70	—	·02	—
21	—	·02	—	·13	—	·34	—	·02	—	·38	—	·33
22	·06	—	3·16	—	·07	—	—	·22	—	·21	·10	—
23	—	·08	—	—	—	1·20	—	—	·65	—	—	—
24	—	—	·03	·22	—	—	·16	·52	·02	—	·19	—
25	—	—	—	·59	—	·84	—	—	—	1·62	·31	—
26	—	—	—	—	·58	—	—	—	—	·61	2·15	—
27	·13	—	·16	—	—	—	—	·03	—	·15	·13	1·07
28	—	—	·20	—	—	—	—	·02	—	·01	·23	·01
29	·91	—	—	—	—	—	—	—	—	—	1·52	—
30	·38		—	·87	—	—	—	·08	·04	1·86	·06	2·03
31	—		2·86		—		—	—		·16		—
	7·07	1·69	12·82	6·65	7·58	3·28	4·62	4·02	1·71	10·37	14·84	10·27

Total for the year 84·92 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1937

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	—	·86	—	—	—	—	—	—	·34	1·52	·37	·86
2	—	1·38	·01	—	·05	—	·56	—	·06	—	—	·69
3	·35	—	·25	—	—	—	—	—	·42	·05	—	·06
4	—	·04	—	·57	·10	—	—	—	·73	—	—	·05
5	—	—	—	·02	—	—	—	—	—	—	1·36	·37
6	—	—	—	·05	·78	—	·37	—	—	1·33	—	·65
7	—	—	—	1·06	—	2·00	·06	·12	—	·13	1·08	—
8	—	—	—	—	·37	—	—	·25	—	—	—	·42
9	·33	—	—	—	—	—	·83	—	—	—	·27	—
10	—	—	—	—	—	—	·06	—	—	—	·06	—
11	·69	·81	·05	1·01	—	·08	—	—	·53	—	—	—
12	3·89	—	1·22	—	—	—	·58	·20	·31	·02	—	·95
13	—	—	—	·45	·27	—	—	—	·02	—	1·21	·06
14	—	·68	—	·39	·10	—	—	—	—	—	—	—
15	·66	·72	—	—	—	·07	—	·77	·09	·04	—	1·80
16	1·70	·23	—	—	·24	·14	—	1·31	1·71	—	·46	1·68
17	—	·63	—	·01	·20	—	—	—	—	—	—	·47
18	—	·12	—	·36	1·20	—	—	1·17	—	—	·61	·92
19	—	—	·41	·26	·06	—	—	—	—	·33	1·83	·55
20	—	—	—	·15	—	—	—	·50	·07	·85	—	1·20
21	—	1·13	—	—	—	—	—	—	·80	·17	·21	·34
22	1·20	—	·02	·28	—	—	·06	—	·04	·02	·06	·76
23	—	—	·04	·33	—	—	·09	—	·17	—	·86	—
24	—	—	—	2·51	—	·68	—	—	·03	·40	·25	—
25	·92	·03	·02	·94	·08	·01	—	—	1·51	·06	—	—
26	·33	—	—	—	—	—	—	·34	·68	·72	1·64	1·45
27	·03	·28	2·04	—	3·16	·04	—	—	·04	·02	—	—
28	—	—	—	·64	—	—	—	—	—	—	—	—
29	—		—	·49	—	—	—	—	—	1·01	·35	—
30	—		·51	—	1·21	—	—	—	—	·09	—	·08
31	—		—		·34		—	—		—		—
	10·10	6·91	4·57	9·52	8·16	3·02	2·61	4·66	7·55	6·76	10·62	13·36

Total for the year 87·84 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1938

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	—	—	·23	·25	—	1·01	—	2·12	·11	—	—	—
2	1·23	1·08	—	·05	1·15	—	—	·51	—	·37	—	—
3	·39	·04	—	·37	·13	—	·19	—	—	—	—	—
4	—	—	—	1·16	1·16	—	—	—	·99	—	—	—
5	·02	—	—	·21	—	2·16	—	—	—	·67	—	·25
6	—	3·59	·25	·39	·19	1·82	—	—	—	—	·96	·55
7	—	2·31	—	—	—	—	—	—	·11	·06	·40	2·48
8	3·28	—	·20	—	—	—	—	—	—	—	·05	·22
9	—	·70	—	—	·03	—	—	—	—	—	—	·02
10	—	·20	—	·93	·24	—	·38	—	—	—	—	—
11	—	—	1·06	—	—	—	—	—	—	·15	·07	·14
12	—	—	—	—	—	·05	·71	·04	·76	1·27	·25	·53
13	—	·16	1·21	—	—	1·11	·23	·59	·26	—	—	—
14	—	—	·19	·34	·17	—	·63	—	—	—	—	—
15	—	—	—	—	—	·11	—	—	—	—	—	·73
16	·18	—	·55	—	—	—	—	—	—	·16	·32	·42
17	—	—	·59	—	·39	—	—	·11	—	—	·03	—
18	—	—	·19	—	1·51	—	—	—	2·62	—	·22	—
19	·09	—	—	·02	—	—	—	·14	—	—	—	—
20	·09	—	—	—	—	—	—	·16	—	·20	—	·33
21	—	—	1·35	·25	—	—	·10	—	·18	—	·02	·33
22	—	—	1·02	1·01	·06	—	—	·10	·72	—	·37	—
23	·10	—	—	—	—	·77	—	—	—	—	—	—
24	·35	—	·09	·46	1·01	—	—	·27	—	1·01	·08	—
25	·77	—	—	—	—	—	—	1·11	·02	·52	—	—
26	·10	·10	·17	1·22	—	—	—	—	—	2·37	—	—
27	2·79	·70	·04	·91	—	·61	—	—	—	·22	—	1·18
28	·08	·38	—	—	—	—	—	—	—	·03	1·02	·07
29	·19		—	·07	·61	—	—	—	1·57	—	·16	·07
30	·07		1·28	—	—	·91	—	—	—	—	—	—
31	·52		·38		—		—	1·78		·15		—
	10·25	8·88	8·80	7·64	6·65	8·55	2·14	6·93	8·34	7·03	6·25	9·20

Total for the year 90·66 inches.

RAINFALL, IN INCHES, AT THE BOTANIC GARDENS, SINGAPORE

1939

	January	February	March	April	May	June	July	August	Sept.	October	Nov.	Dec.
1	·02	—	·28	—	—	—	—	·07	·83	·08	1·41	1·88
2	·11	—	—	—	—	·09	·41	·41	—	—	—	—
3	—	·71	1·54	—	—	—	—	—	·05	·17	·04	—
4	—	—	—	·01	—	·32	—	—	—	1·38	—	—
5	·62	1·18	·77	·68	—	—	—	—	—	—	—	·21
6	—	·15	—	·52	—	—	·36	·75	·45	—	—	·14
7	·42	·49	—	—	·20	·99	—	3·75	—	·36	1·76	·34
8	—	·11	·08	2·98	·49	—	—	—	—	—	·09	—
9	—	—	·27	—	1·00	—	—	·01	—	—	—	·27
10	—	—	—	—	—	1·66	—	—	—	1·68	1·02	—
11	—	—	—	—	—	—	—	·10	—	1·01	·16	—
12	—	—	—	·45	·45	—	·22	—	·83	1·03	1·13	·11
13	·94	—	—	·13	·13	—	—	—	1·76	·37	—	—
14	—	—	—	·53	·53	—	—	—	·07	—	·03	7·63
15	—	—	—	—	—	·38	—	1·82	·45	·58	—	·68
16	—	—	—	·82	·82	·06	—	·07	—	—	—	2·27
17	·12	—	—	—	—	—	—	1·33	·28	—	·06	—
18	—	—	—	—	—	—	1·21	1·18	·70	·22	—	—
19	·55	—	·20	—	—	1·55	—	—	—	·03	—	—
20	·51	—	—	—	—	—	—	—	·22	—	—	—
21	—	·57	—	—	—	—	—	—	·03	·19	·19	·13
22	·12	·44	—	—	—	—	—	—	—	·19	—	—
23	·44	—	—	—	—	—	·07	—	—	—	—	—
24	1·11	·05	—	—	—	—	—	·02	3·89	·23	1·23	—
25	·08	—	—	—	—	·13	·35	·09	—	—	—	—
26	·14	—	·53	·92	·92	—	—	—	—	·27	—	·04
27	·04	1·73	—	—	—	—	—	1·70	—	·34	1·47	—
28	—	—	—	—	—	·02	—	2·21	—	—	—	·005
29	—		—	—	—	—	·90	—	—	—	1·14	—
30	—		·78	·55	—	—	—	·38	—	·53	—	—
31	2·22		—		—		·77	2·01		—		·08
	7·44	5·43	4·45	7·59	4·54	5·20	4·29	15·90	9·56	8·66	9·73	13·78

Total for the year 96·57 inches.

PUBLICATIONS OF THE BOTANIC GARDENS, SINGAPORE

1. **The Agricultural Bulletin of the Malay Peninsula** [Old Series] nos. 1–9, 1891–1900 (out of print).

2. **The Agricultural Bulletin of the Straits and F.M.S.** [Second Series, monthly issues] Vols. 1–10, 1901–1911. Most numbers are available, price 50 cents each or $5 per volume.

3. **The Gardens Bulletin, Straits Settlements.**

   Vol. 1 nos. 1–5, January to May 1912 (as *Agricultural Bulletin of the Straits and F.M.S., Third Series*). nos. 6–12, December 1913—March 1917 (as *The Gardens Bulletin, S.S.*).

   Vol. 2 nos. 1–12, July 1918—August 1921.

   Vol. 3 nos. 1–12, August 1923—March 1925.

   Vol. 4 nos. 1–12, June 1926—January 1929.

   Vol. 5 nos. 1–12, August 1929—June 1932.

   Vol. 6 nos. 1–15, (issued as parts 1–3) December 1929—October 1930.

   Vol. 7 parts 1–3, September 1932—June 1934.

   Vol. 8 parts 1–4, October 1934—October 1935.

   Vol. 9 parts 1–4, December 1935—March 1938.

   Vol. 10 parts 1 and 2, January, 1939—August, 1939.

The above former issues of the Gardens Bulletin may be purchased from the Botanic Gardens, Singapore, at $5 per volume or 50 cents per number for vols. 1–5 (Vol. 6, of 15 numbers, $7.50); in some cases two or more numbers were published together. Vols. 7–10 are published at $8 per volume; the prices of parts vary according to their size. The parts are published at irregular intervals, as material is available.

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